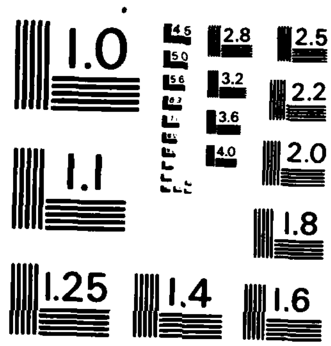
AD-A160 925 A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPE..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. J IBANEZ 1/2

UNCLASSIFIED SEP 85 AFIT/GEM/LSM/85S-7 F/G 5/1 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2

AD-A160 925

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

This [illegible] een approved
for [illegible] sale; its
distri[illegible] ed.

85 11 05 055

2

AFIT/GEM/LSM/85

A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPERATIONS BRANCHES

THESIS

Juan Ibanez Jr.
First Lieutenant, USAF

AFIT/GEM/LSM/85S-7

The contents of the document are technically accurate, and no sensitive items, detrimental ideas, or deleterious information are contained therein. Furthermore, the views expressed in the document are those of the author(s) and do not necessarily reflect the views of the School of Systems and Logistics, the Air University, the United States Air Force, or the Department of Defense.

AFIT/GEM/LSM/85S-7

A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPERATIONS BRANCHES

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Juan Ibanez Jr., B.S.

First Lieutenant, USAF

September 1985

Acknowledgements

I would like to express by appreciation to Major Timothy Beally and Captain Robert Hamel of the School of Civil Engineering for allowing me to use their computer system. Their constant assistance was instrumental in the successful completion of the programming phase of this study. Also, to people of the School of Civil Engineering, thank you for enduring those afternoons when, because of me, your computer barely responded.

I wish to further acknowledge the assistance received from the 2750th Civil Engineering Squadron. Their cooperation in providing the timely and necessary data made this research possible. A special thanks to Mr David Johnston for his guidance in the development of the program software.

Finally, I wish to thank Captain Jeffrey Thomas, advisor, for his understanding and guidance throughout this research effort.

Juan Ibanez Jr.

Table of Contents

List of Figures

List of Tables

AFIT/GEM/LSM/85S-7

Abstract

Performance initiatives by the Office of the Secretary of Defense and the Department of the Air Force have resulted in many strategies to increase productivity, yet no practical nor definitive approach to measure civil engineering productivity now exists. This thesis applies a Project IMAGE productivity indicator designed to quantify the Base Civil Engineering Operations Branch's "Customer Service" output. In concept, the indicator uses estimated work hours, Engineered Performance Standards, applied to job and work orders, and processes these hours against timeliness, quality, facility-type, and work priority factors. The result is a weighted production count which allows relative productivity measurement. The primary objective of the thesis was to demonstrate application of the concept by using the Work Information Management System and data from the 2750th Civil Engineering Squadron. The study produced a computer program to implement the productivity concept. Research results indicate the concept can be applied using data currently maintained by civil engineering. Widespread use of this concept requires additional research.

A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPERATIONS BRANCHES

I. Introduction

General Issue

> For more than 80 years the rate (compounded annually) of productivity growth in the United States rose steadily at an average rate of 2.4 per cent. New machines and methods constantly were being adopted to reduce the amount of hard labor required per unit of goods or service produced. As a result, the average worker today produces four times as much in an hour's work as did his counterpart eight decades ago. These productivity gains have allowed our nation to create new job opportunities, increase per capita income, and enjoy greater leisure--in a word, to pursue the quality of life that we have come to expect [22:5].

However, since 1966 United States productivity gains fell below the post World War II growth rate (22:5), and in general, no productivity growth has been realized since 1977 (11:51). Consequently, never in this nation's history has there been more concern and worry over productivity as there is today (22:2).

Rising budget deficits have focused public attention on the defense establishment and thus, has made the productivity issue more acute among military managers. In the fiscal 1985 budget, for instance, the defense establishment maintains approximately 70 percent of the controllable portion of the budget. With the national debt expected to exceed $1.8

trillion by the end of fiscal 1985 (50:68), Congress and the public are constantly studying the defense establishment looking for ways to trim the budget and fight increasing deficits. Though budget outlays in defense are expected to increase under the Reagan Administration (50:71), examination of how this money is spent can also be expected to increase. Consequently, managers at all levels are being challenged to increase productivity. Constrained resources will continue to be commonplace as public concern over growing deficits and unusually high defense spending draws close scrutiny on military managers. The essence of the issue facing military managers is stated by Louis L. Wilson, Jr., General, USAF.

> The Air Force is facing one of the most austere times in its history. In spite of increased defense budgets our buying power has eroded, with the net result that we have to do more with less. To meet this challenge, we need to fully utilize our most costly and important resource--people--by instilling in them a sense of urgency about their important role in the conduct of the nation's critical enterprise--national security--and in doing so we must increase their productivity [52:2].

Problem Statement

Performance initiatives by the Office of the Secretary of Defense and the Department of the Air Force have resulted in many strategies to increase productivity, yet no practical nor definitive approach to measure civil engineering operations productivity now exists. An objective measurement method is needed to evaluate these proposed strategies and provide civil engineering managers viable options in their daily quest to best allocate available resources.

Research Objective

The primary objective of this thesis is to further develop and test a Project IMAGE (Innovative Management Achieves Greater Effectiveness) generated productivity indicator so Air Force Civil Engineering managers will have a useable tool to determine relative productivity levels. Specifically, the objective is to determine whether the Project IMAGE productivity indicator can be usefully and practically applied to base level Civil Engineering Operations Branches.

Investigative Questions

1. What further factor development is needed to employ the productivity indicator?

2. What computer software is needed to employ the productivity indicator?

3. How do the indicator's computed results generally compare to manager perceptions of productivity?

Scope and Limitations

This thesis will focus only on one productivity indicator proposed by the Project IMAGE Team. Briefly, the Project IMAGE Team stated the civil engineering product area, Sustain Real Property, is composed of three overlapping areas: (1) Facility Appearance, (2) Facility Condition Indexes, and (3) Customer Service. Using the team's proposed productivity indicator, this thesis will attempt to measure the Wright-Patterson AFB, 2750th Civil Engineering Squadron, Operations Branch's contribution to the component area

Customer Service. While there certainly may be application of the concept to other civil engineering organizations, this thesis is a "first step" to demonstrate actual application of the concept and provide a starting point for later research.

Definitions

The focus of this thesis is to develop a productivity indicator to assess the Customer Service component of the civil engineering product area Sustain Real Property. However, no accepted definition of the term Customer Service exists nor has one been proposed by the Project IMAGE Team. Consequently, for the purpose of this thesis a definition should be constructed. I will start by reviewing the 2750th Air Base Wing and Civil Engineering Squadron mission statements.

According to Air Force Logistics Command Regulation 23-4 the wing's mission "is to operate and maintain the Wright-Patterson Air Force Base" (39:1). Further, the regulation states the Air Base Wing Commander is tasked to provide civil engineering services. The Civil Engineering Squadron Commander is tasked with those duties as delegated to him by the Air Base Wing Commander.

> [He] ensures the proper planning for, and management of Air Force real property, provision of utilities, maintenance and repair of facilities and real property installed equipment, fire protection and rescue. Manages the Base Engineering Emergency Forces (BEEF) program [39:appendix 15,page 1].

While the regulation does provide some direction, it is general in nature and further guidance is needed to develop a definition for Customer Service.

In a May 1984 report titled "Performance Management Indicators," the Project IMAGE Workshop labeled Customer Service as:

> Customer Service. The maintenance, repair and minor construction done to satisfy direct customer requests for service can be done in-service through job orders and work orders or by contract in 52X projects [40:6].

This statement is too narrow. The phrase "satisfy direct customer requests" fails to account for some indirect customer requests such as the Recurring Work Program. Recurring work performed by civil engineering is internally (from within civil engineering) generated and is not associated with a direct customer request. Nevertheless, the Project IMAGE statement does provide a good foundation that can be combined with aspects of the Air Base Wing and Civil Engineering mission requirements.

Before defining Customer Service one more aspect needs to be introduced--level of service. To provide service alone is not enough, an acceptable quality must be provided within an acceptable time period. For example, partially repairing a leaking pipe three weeks after the customer request is not an acceptable level of service when the customer needed the leak fully stopped within three days.

Combining the above statements, a definition of Customer Service for the Operations Branch can now be constructed.

> Customer Service is the acceptable work accomplished by civil engineering to meet the mission requirements of the installation.

This definition is flexible, while at the same time both broad and specific. Flexible in that work can be in the form

of maintenance, repair, construction, or "no class" work. Further, it makes no distinction on how the work is to be accomplished, work/job orders, recurring work, etc. The definition is also broad to encompass the requirements levied by the mission. Finally, it is specific, acceptable work must be done. Acceptable both in timeliness and quality. Timeliness and quality criteria will be established in Chapter V, Results and Analysis.

II. Review of the Literature

Overview

This chapter will review the current literature on productivity. The chapter will begin by examining the concept of productivity. In review, productivity is defined and its measurement and benefits are discussed. Second, Department of Defense productivity initiatives are presented. This discussion is important to understand the current emphasis for productivity within Air Force Civil Engineering. Finally, this chapter concludes with a literature review of productivity in USAF Real Property Maintenance. The review highlights past initiatives and studies done on productivity in this area.

Background on Productivity

Productivity is an elusive term, frequently used and studied, but often misunderstood. Consequently, an understanding of productivity is an essential first step to measuring it. An obvious beginning point in this pursuit is to define productivity.

What is Productivity? *Webster's New International Dictionary* defines productivity as:

> Quality or state of being productive; productiveness; as, literary or racial productivity [51:1975].

The term productive is defined as:

> 1. Having quality or power of producing; bringing forth, or able to bring forth, esp. in abundance; generative; creative; fertile; as, productive soil, races, or imaginations. 2. Effective in bringing forth or forward; originative; causative; --with of; as, a situation productive of evils. 3. Yielding or furnishing results, profits, or benefits; as, productive enterprises or legislation [51:1975].

In carefully studying the Webster dictionary's definition it becomes apparent that productivity is not an easy concept to define. In fact, Paul Mali in his book Improving Total Productivity stated:

> The views of productivity for purposes of definition and understanding have not been consistent or uniform. In fact, the many views of productivity have contributed to confusion and obscurity about its nature....Years of seeking productivity growth should have yielded an acceptable meaning. This is not the case, probably due to different positions and emphasis in productivity processes and measurements [26:4].

To illustrate Mali's statement, many differing definitions of productivity found in the current literature could be presented. This would, however, only further complicate the issue and perhaps distort the original context and intent of the definitions. Instead, it is best to first present two key concepts, efficiency and effectiveness, and then examine how these concepts combine to provide a good definition of productivity.

Efficiency is generally recognized as the ratio of outputs to inputs or amount of output per unit of input (1:18). Efficiency is increased when less inputs are required for a specified level of output. Efficiency, therefore, emphasizes attaining maximum output with a minimum input. It is with this emphasis that many managers confuse

efficiency and productivity, thinking them synonymous, and attempt to cut input cost while maintaining output levels (9:19). This view can result in service being provided at the lowest cost without regard to quality (9:13). Thus, efficiency alone is not a good indicator of productivity. Another concept--effectiveness--must be considered.

Effectiveness is the relationship between an organization's outputs and its objectives; "the more these outputs contribute to the objectives, the more effective the unit is" (1:19). In essence, effectiveness relates to the direction of effort. Again, as efficiency alone was not a good indicator of productivity, such is the situation with effectiveness. Together, however, they provide a good insight to productivity (6:16; 9:14; 13:17).

Combining the concepts of efficiency (outputs to inputs) and effectiveness (goal attainment) provides a framework for defining productivity. Working from such a framework, Captains Baker and Kennedy expressed the following:

PRODUCTIVITY LEVEL = EFFICIENCY X EFFECTIVENESS

(Note, efficiency and effectiveness both must be positive for the productivity level to be greater than zero) (3:182).

In sum, productivity can be defined as "the degree to which specific goals were achieved (effectiveness) and the level to which the effort was expended (efficiency)" (3:183). Stated another way, productivity is the efficient use of available resources to achieve results congruent with the organization's goals (5:24).

How is Productivity Measured? Measuring productivity is not an easy task considering the many varied organizational structures and their accompanying operations. Nevertheless, productivity measurement is a valuable management tool and many approaches to measurement have been attempted.

Captains Baumgartel and Johnson presented four categories of productivity measurement. The first category, financial ratios, is a comparison of financial outputs to financial inputs (5:12). They are used to circumvent the problems associated with assessing the contribution of different inputs to the production of a product. Some examples are profit/investment (return on investment), profit/revenue (operating profitability), and revenue/investment (capital turnover) (5:12). The second category, productivity costing, attempts to quantify the productivity of a product by measuring its ability to make a profit (5:12). Third, transfer pricing, "compares the cost of producing a product or component which is to be further processed by the organization against the cost of obtaining the product from a competitor" (5:12). Caution, however, should be exercised because both managers, the buyer and seller within the organization, want to maximize profits (28:864). This can lead to unnecessary buying from a competitor and loss of profits for the organization. Finally, other empirically-oriented approaches to productivity measurement include such methods as "value added per product, unit cost, actual output to potential output, and percent of output rejected" (5:13).

The four categories of productivity measurement presented above are basically oriented to organizations in industry, their application to nonprofit or service organizations such as Air Force Civil Engineering present difficulties. The most significant difficulty is the absence of a profit measure.

Discussing nonprofit organizations in their book, Management Control in Nonprofit Organizations, Anthony and Young, present nine characteristics of nonprofit organizations, the most important is the absence of a profit measure.

> The absence of a single, satisfactory, overall measure of performance that is comparable to the profit measure is the most serious problem inhibiting the development of effective management control systems [e.g. productivity measurement] in nonprofit organizations [1:39].

They further stated:

> The profit measure has the following advantages: (1)it provides a single criterion that can be used in evaluating proposed courses of action; (2) it permits a quantitative analysis of those proposals in which benefits can be directly compared with costs; (3) it provides a single, broad measure of performance; (4) it permits decentralization; and (5) it facilitates comparisons performance among entities that are performing dissimilar functions [1:39].

Anthony and Young relate that most nonprofit organizations have a tendency to be service organizations and the absence of a profit measure creates problems when attempting to quantify the output. Conversely, inputs to service organizations can be readily measured, as in a profit-oriented organization (1:42). In sum, service organizations, such as civil engineering, need to focus on quantifying their outputs in an effort to measure productivity.

Output information is needed to measure efficiency and effectiveness (1:467), the two key constituents of productivity. Anthony and Young present three basic measurement categories for output in service organizations. The first is results measure. Results measure "is a measure of output expressed in terms that are supposedly related to an organization's objectives" (1:468). However, at times a results measure cannot be quantified so a surrogate or proxy measure is obtained (1:468). For instance, an objective to plan civil engineering work as economically as possible is difficult to quantify. Perhaps a surrogate measure such as percent of work orders on "job stoppage" could measure the objective. A second category of output measures, process measures, pertains to an activity performed by an organization (1:468). For example, in civil engineering this can be the number of work orders processed by the Customer Service Unit in one month. Not to be confused with results measure, process measure is "means oriented," whereas the former is "ends oriented" (1:468). Social indicators are the final category of output measures. "A social indicator is a broad measure of output which is significantly the result of the work of the organization" (1:471). For example:

> The crime rate in a city may reflect the activities of the police department and the court system, but it is also affected by unemployment, housing conditions, and other factors unrelated to the effectiveness of these organizations [1:471]

Social indicators are difficult to "use properly because there is no demonstrable cause-effect relationship" (1:471).

In sum, productivity measurement is a difficult task at best. Problems arise in selecting the proper approach and quantifying the appropriate elements. This task is especially difficult in nonprofit organizations because of the absence of a profit measure. Consequently, organizations must decide on appropriate measures and tailor them to the organization's particular needs.

Why Measure Productivity? Productivity measurement provides management with a valuable tool to rationally direct the organization. In general, productivity measurement helps the manager determine organizational accomplishment, future direction, and creates awareness (11:64-65). Specifically, "formalized yardsticks of work [productivity] measurement and accountability can practically guarantee any company a 15 % minimum direct labor cost reduction " (27:36). Paul Mali elaborated on these aspects when he presented thirteen benefits derived from Managing Productivity By Objectives (MPBO). Though MPBO is a specific form of productivity measurement, it can be argued, the benefits and implications presented can apply to other forms of good productivity measurement. Three benefits of MPBO which Mali present provide particular insight into productivity measurement.

1. Scorekeeping. Productivity measurement allows management to evaluate organizations, departments, or programs by comparing productivity measurement data (25:17). Scorekeeping is difficult, however, when attempting to evaluate units with different objectives, constraints, resources, etc.

2. Better Decision Making for Budget Programming and Control. Productivity measurement allows management to rationally shift resources to best meet the needs of the organization (25:18).

3. A New Resource. Proper application of productivity measurement can lead to productivity gains and this can be perceived as an untapped resource (25:18).

James H. Donnelly and others in their book Fundamentals of Management summarized the many benefits of productivity measurement (11:64). These benefits are shown in figure 1.

MANAGING WORK AND ORGANIZATION

-Establish goals
-Call attention to management process.
-Aid in decision making.
-Justify expenditures.
-Communicate efficiency.
-Serve as a planning tool.

MANAGING PEOPLE

-Place emphasis on results.
-Introduce short- and long-term perspectives.
-Provide feedback.
-Identify training and development needs.

MANAGING PRODUCTION AND OPERATIONS

-Illustrate sales, expense, profit relationship.
-Improve budgeting decision making.
-Establish standards.
-Aid in work-place design decisions.
-Facilitates comparisons across time periods.

Figure 1. Uses of Productivity Measures.

Productivity measurement provides many benefits to an organization, and these benefits can be reaped at all levels. In sum, productivity measurement can lead to improved performance.

Productivity Initiatives in the Department of Defense

Today more than ever the Department of Defense (DOD) is concerned with productivity enhancement. Concern for productivity enhancement within DOD is not new; in fact, as early as the 1900's, the scientific management principles of Frederick Taylor were tested at Army arsenals and Navy shipyards (9:11). Today, the DOD productivity program begins with DOD Directive 5010.31 and DOD Instruction 5010.34.

In August 1973 the DOD established a permanent productivity program and implemented it through DOD Directive 5010.31 (48:encl 3). The directive stated management attention must focus on,

> ...achieving maximum Defense outputs within available resource levels by systematically seeking out and exploiting opportunities for improved methods of operation, in consonance with the Defense Preparedness mission [47:1].

The directive further stated the program will be labor oriented, but it does allow the use of a total factor or unit cost measures in addition to labor base productivity measures (47:2). In essence, the directive recognized the need for DOD managers to be productivity conscious. Though the directive does not provide specific guidance, it does attempt to better focus DOD's overall productivity enhancement effort by bringing into perspective related DOD initiatives.

The second document that forms the foundation of the DOD Productivity Program is DOD Instruction 5010.34. The Instruction begins by reiterating the objective of the DOD program--"to achieve optimum productivity growth throughout the DOD" (48:1). This document, however, addresses the topic more specifically than DOD directive 5010.31. It establishes goals for the head of each DOD component and provides an outline for productivity enhancement methods and standards; productivity measurement and evaluation; productivity reporting; and fast-payback capital investment opportunities (48:4). Enclosure three of the Instruction suggested three productivity indicators for Real Property Maintenance Activities.

1. Area of buildings maintained.
2. Amount of refuse collected.
3. Quantity of electric generated.

Later in this chapter it will be shown these are poor indicators of productivity measurement when applied to Air Force Civil Engineering organizations.

More recently, Office of Management and Budget (OMB) Circular A-76 of March 1979 has forced DOD agencies to perform efficiency reviews on those activities identified for possible conversion to private sector contract operation (44:2). These reviews have resulted in converting many government commercial activities to private sector operations with a resultant cost savings to the DOD (24:1). Equally important, however, was that the reviews prompted in-house

activities to be more efficient in order to compete with private contractors (44:1). As a result, in September 1981, the General Accounting Office (GAO), in a letter titled "Expanding the Efficiency Review Program for Commercial Activities Can Save Millions," recommended that the Secretary of Defense expand the OMB Circular A-76 concept to all commercial activities (18:3). As a result of the GAO recommendation, the Secretary of Defense in November 1981 expanded the efficiency review process to include 12,000 commercial activities not previously affected (44:3). The goal of the process is,

> ...to increase productivity through accomplishment of each Service's mission in the most cost effective manner, without decreasing mission effectiveness [44:-].

On 17 January 1983, Air Force Civil Engineering initiated its portion of the mandated efficiency reviews by conducting the Real Property Maintenance Activity Prelimi.ary Review Workshop. Subsequently, the civil engineering effort has become known as Project IMAGE, and held its charter workshop in May 1984. Major General Clifton D. Wright, Director of Air Force Engineering and Services, stated the purpose of Project IMAGE is to improve base level productivity by eliminating constraints and providing flexibility to civil engineering managers (53:4).

In sum, DOD's concern for productivity enhancement is evident. DOD Directive 5010.31 and DOD Instruction 5010.34 form the foundation of DOD's productivity enhancement program. Further, initiatives such as the Secretary of Defense's mandated efficiency reviews serve to fulfill the

intent of the program. The implication to AFCE managers is clear: the push for productivity enhancement from without must be matched by equal emphasis from within.

Productivity in USAF Real Property Maintenance

As discussed in the previous section, productivity enhancement in Real Property Maintenance Activities has been the subject of significant concern to managers. This concern has prompted many studies aimed at improving real property maintenance productivity. One study by McKinsey determined that approximately 85% of the factors affecting productivity enhancement are in the control of management (23:5-6). Therefore, prior to discussing real property maintenance productivity studies, it is important to understand management in maintenance activities.

Maintenance management is an integrated system designed to provide control over maintenance work from discovery to completion (41:1). Maintenance management has four objectives.

1. Provide proper and consistent levels of maintenance.
2. Increase work force productivity.
3. Reduce maintenance costs.
4. Provide appropriate response to Command requirements. [41:1]

To accomplish these objectives, four aspects of maintenance management are needed: (1) work generation, (2) work control, (3) scheduled accomplishment, and (4) appraisal (41:2). Figure 2 shows these aspects and the related components.

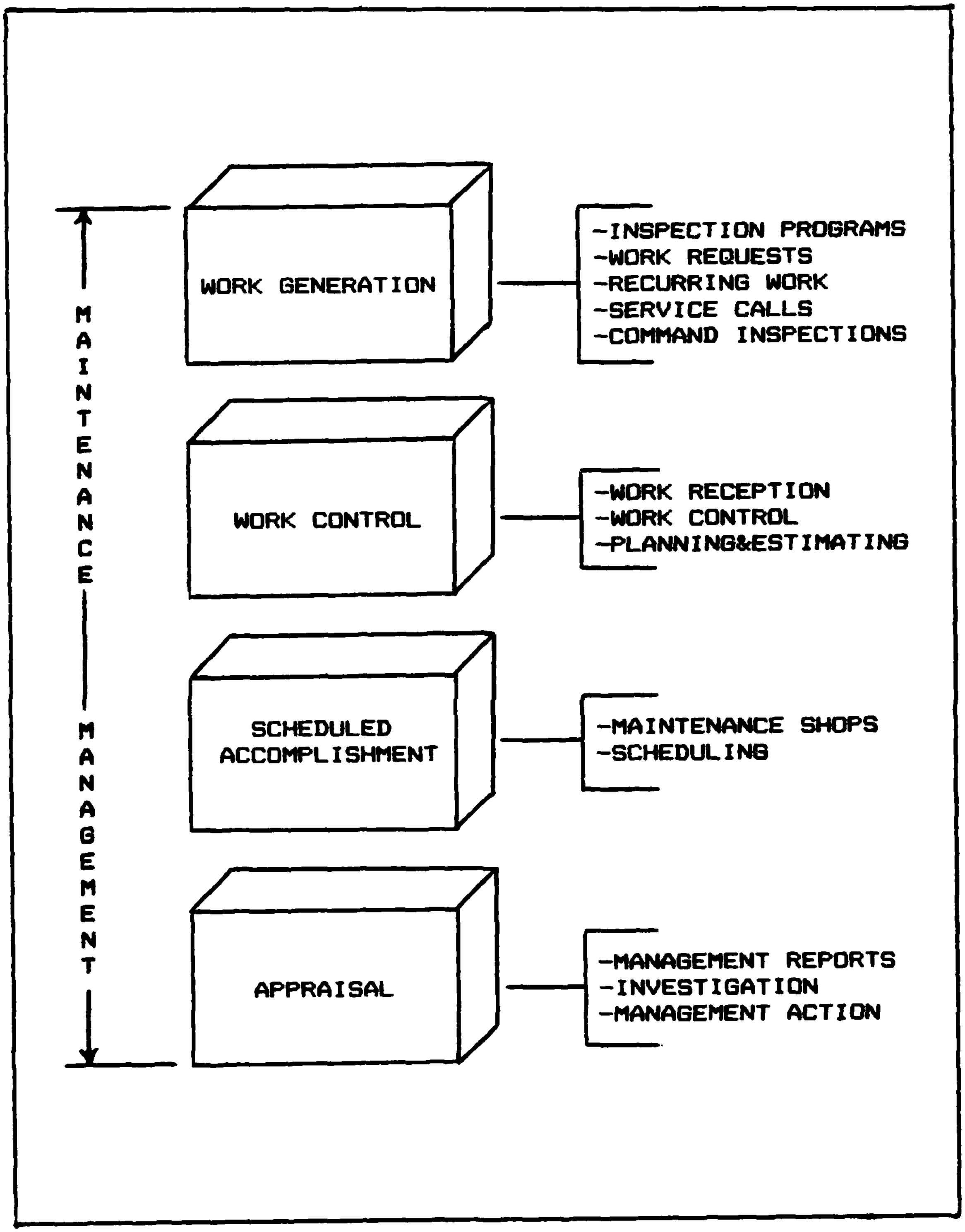


Figure 2. Four Aspects of Maintenance Management.

The definition of maintenance management states it is an integrative process. That is, each aspect and component must be coordinated and act in concert with the other aspects and components if overall maintenance management is to perform well.

In sum, management directly impacts the productivity of Real Property Maintenance Activities. And, maintenance management is the system used to control work within maintenance activities. Having defined maintenance management, a discussion of productivity studies in USAF Real Property Maintenance begins.

In 1979 Major Havey D. Chace identified three shortcomings in measuring civil engineering shop labor productivity.

> 1. A lack of recognition of Air Force Civil Engineering's role as a service industry and not a manufacturing or construction enterprise. This has led to an emphasis on maximizing units of output instead of level of services.
>
> 2. An overemphasis on internally generated labor utilization data which reflect efficiency more than effectiveness.
>
> 3. A lack of a business like approach to analyzing the role and mission of Air Force Civil Engineering. That is, the unit fails to view output from the standpoint of the customer.
>
> [9:12]

Major Chace stated "failure to recognize Base Civil Engineering as a service industry has been one of management's major short comings" (9:16). He believes that customer satisfaction should be as carefully measured as estimated versus actual manhours per task. As he learned, Air Force Civil Engineering reports the productivity of shop

personnel to the Defense Integrated Management Engineering System by submitting a comparison of labor hours to floor space (9:15). However, such a productivity indicator allows for productivity increases by merely lowering labor hours while at the same time providing poorer service to the floor space maintained (9:15). As stated earlier, this was a suggested productivity indicator for Real Property Maintenance Activities in DOD Instruction 5010.34.

Major Chace's solution to the three shortfalls he identified was to use the claimant model as presented by Cleland and King in their book, Management: A Systems Approach. This model attempts to describe the organization in the context of "Who is our customer?" and "What does he buy?" Under such a framework, productivity initiatives are then evaluated.

Later productivity analysis of the Base Civil Engineering organization by the USAF Directorate of Engineering and Services and Decision Dynamics Inc. focused on improving productivity, not measuring it (42:3). The study found seven general factors affecting productivity.

1. Labor. Labor, or people, contain a mix of abilities, skill, experience, knowledge, etc, and form the basic productivity factor (42:4). Essentially, it is through people that work is accomplished.

2. Technology. Efficient use of labor depends on using tools and equipment that are at the appropriate level of technology for the job. (42:4).

3. Planning and Design. Planning and Design include materials selection, job layout, timing, manning, methods, and organization (42:4). These factors are important to maintenance management, and can significantly affect overall productivity.

4. Physical Environment. Physical environment includes such conditions as location, climate, noise, etc. Physical environment can also include distance to job, traffic flow, accessibility to job site, and energy availability. The physical environment factors normally assume importance when they detract from productivity (42:4).

5. Regulations. Rules and regulations serve to provide consistency and safety in operating procedures. While some rules contribute to efficient operation, others are inflexible and do not "bend" to fit certain situations, thus may adversely affect productivity (42:5).

6. Off-job Environment. The military installation can be considered a small community in itself; a community where much of the labor force resides. Therefore, the facilities and functions provided by the installation play a role in shaping the work force's attitude, and ultimately their work performance (42:5).

7. Management. Management and supervisory personnel exert different degrees of control over productivity factors. For instance, much control is exerted over job planning and scheduling, while little control is exercised over regulations and physical environment (42:5).

The study stated all of the factors must be maximized otherwise some productivity loss will be encountered (42:35). They identified poor planning as the single biggest obstacle to productivity improvement (42:32). Another study performed by McKinsey indicated about 85% of the factors affecting productivity are internal to the organization and in the control of management (23:5-6). Thus, the seventh factor, management, plays a major role in improving productivity. As a conclusion to their study, Decision Dynamics presents specific factors that cause productivity losses in the Base Civil Engineering organization, shown in Figure 3 (42:36). The factors in the figure are grouped in three categories: (1) excess overhead cost, (2) excess materials cost, and (3) excess labor. These factors concentrate on causes of productivity loss that are usually under the control of civil engineering management (42:35).

Other studies on productivity and performance in USAF Real Property Maintenance have been conducted by graduate students in Engineering Management at the AFIT School of Systems and Logistics. In 1974, Captains Arnold and Fink stated that the civil engineering manager suffered from an over abundance of irrelevant information. Consequently, their research focused on identifying civil engineering organizational objectives; performance indicators needed to monitor these objectives; and finally, frequency with which the indicators needed to be reviewed (2:21). They concluded "Provide required Real Property Facilities to support the base mission at least cost" as the overall objective in base

Causes of BCE Productivity Losses

excess overhead cost

-excess supervisors
-excess support personnel
-inadequate support

excess labor cost

working below capacity

-lack of skills
-manning problems
-poor work conditions
-lack of clear directions
-lack of clear directions
-failure to use best practice
--inadequate tools/equipment
--failure to use best method
--unfamiliar task
--skills inadequate for task
--inadequate materials
--union imposed work restrictions
-wasted time
--excess start/stop
--excess transit time
--excess movement of materials/equipment

excess rework

-error
-change in plans

not working

-accident
-awaiting
--material
--tools/equipment
--other trades
--transportation
--instruction
-time diverted
--excess transit
--excess training
--excess personal time
--idle due to overmanning

excess material cost

-waste
-loss
-bad design

Figure 3. Causes of BCE Productivity Losses.

level facility maintenance. From the overall objective, they further identified 39 sub-objectives and the corresponding performance indicators (2:53).

In 1976, Lt Col Hanley and Capt Smith demonstrated that standard and adjusted work estimates generated by civil engineering work planners were unreliable when compared to actual manhours expenditures. Consequently, productivity ratios based on standard/adjusted work estimates are also unreliable (21:73). [It should be noted that standard work estimates or engineered performance standards were not as refined and widely used as they are today. This aspect is discussed in a later section on Engineered Performance Standards.]

In 1979, Captains Baumgartel and Johnson conducted a study to develop a model to measure productivity in a base level civil engineering organization. Essentially, their research developed strategic goals and corresponding branch level objectives for the civil engineering organization (5:104). For each goal and objective, related performance indicators were identified. To measure productivity they stated:

> Productivity will be measured as the average value of the performance indicators for each objective divided by the total resources used to attain the level of output of the specific branch level activities contributing to each objective [5:24].

Measuring productivity in this manner presupposes that each performance indicator equally contributes to the objective.

In 1983 Captains McKnight and Parker developed an organizational effectiveness model for base level civil

engineering units by gathering information from wing, base, and civil engineering squadron commanders. Their study identified nine factors which contribute to the organizational effectiveness of a base level civil engineering unit (26:112). Figure 4 depicts the functional model. The order of importance of the nine factors can be seen from the figure: one, fire protection, being the most important and nine, customer image, being the least important (26:93-96). Although of no value in the model's development, productivity was one of five criteria considered most important by all respondents (26:96).

In 1984, Lieutenant Fisher used the Constrained Facet Analysis (CFA) modeling technique to determine if a quantitative model could be used to allocate available resources in the base level Civil Engineering Operations Branch (13:-). Lieutenant Fisher concluded the CFA method could efficiently allocate available resources. Although efficient allocation of available resources would most certainly improve productivity, in this researcher's opinion, the CFA technique is somewhat complicated and use at the base level would probably be limited due to the model's computer requirements.

Though research has proposed varying techniques, base level civil engineering operations managers assess productivity primarily by using a multitude of indexes and relative measures (32:4-21; 34:23-36). For example, productivity of work orders is evaluated by comparing

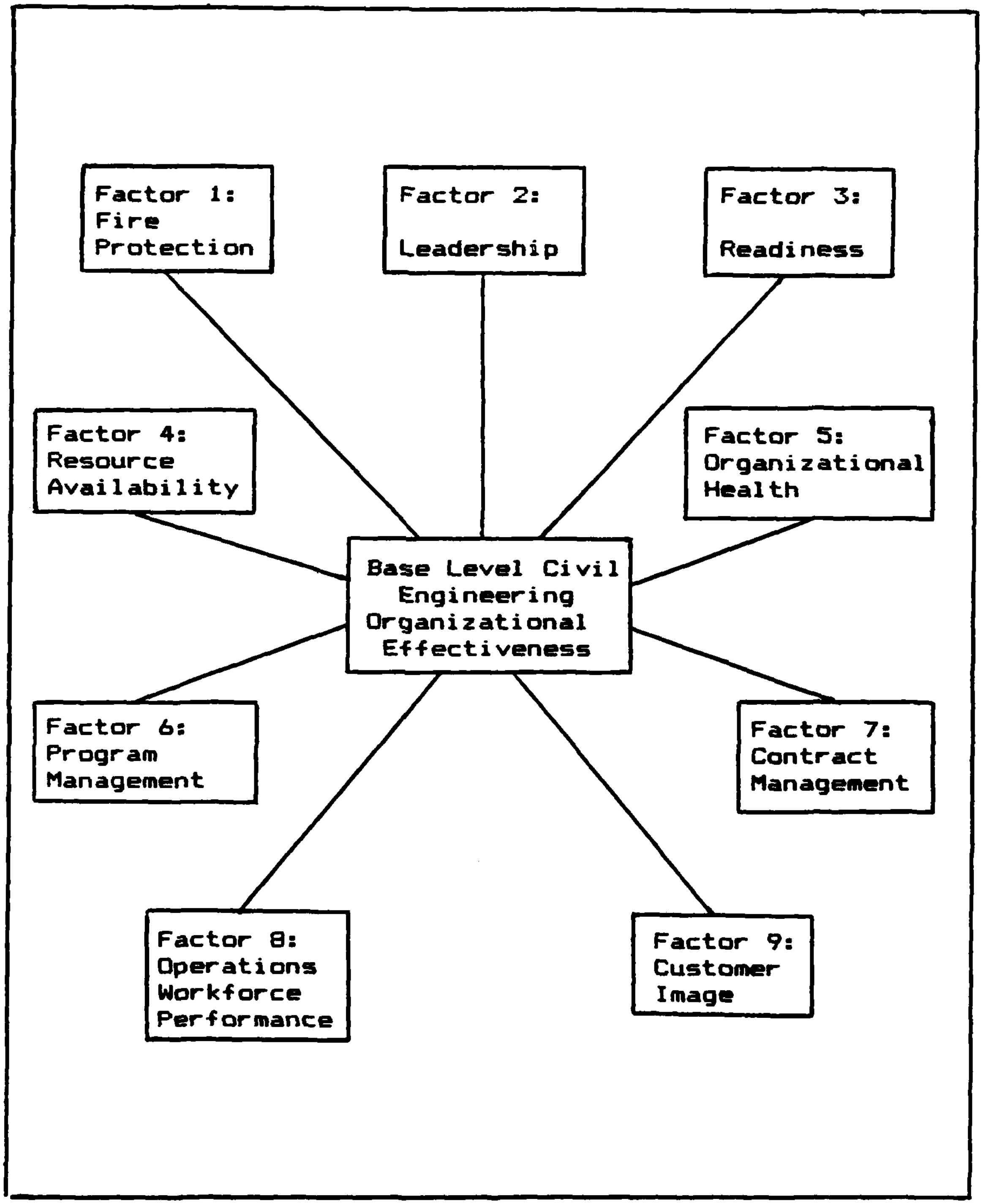


Figure 4. Functional Model of Organizational Effectiveness.

estimated manhours to actual manhours, or backlog of urgent job orders is compared to last week's total or some specified level. While allowing some assessment of productivity, these measures do not actually measure it. As a result, a quantitative measure of productivity is currently being sought by civil engineering managers.

During the January 1983 Real Property Maintenance Activity Functional (RPMA) Review Preliminary Workshop a results oriented approach [quantitative] to productivity was presented (44:13). The workshop first categorized USAF RPMA into the following eight primary product areas (45:IMC83-2):

1. Provide real property.
2. Sustain real property.
3. Ensure readiness.
4. Provide utility services.
5. Establish the physical environment.
6. Provide fire services.
7. Provide non-real property services.
8. Provide technical and management services.

Each product area was then reduced to sub-product areas and tasks (44:13). For example (44:18),

1. <u>Product Area:</u> Sustain real property.
2. <u>Sub-product Area:</u> Maintain/repair facilities.
3. <u>Task:</u> Alter facilities to support mission.

The workshop stated an input-output measurement can be made at the sub-product level by using tasks as the measurement points (44:27). Further, the output is measured against a standard which is established in terms of that

output. For example, the output may be direct labor hours and the standard could be 70 percent of total labor hours. Figure 5 shows this concept.

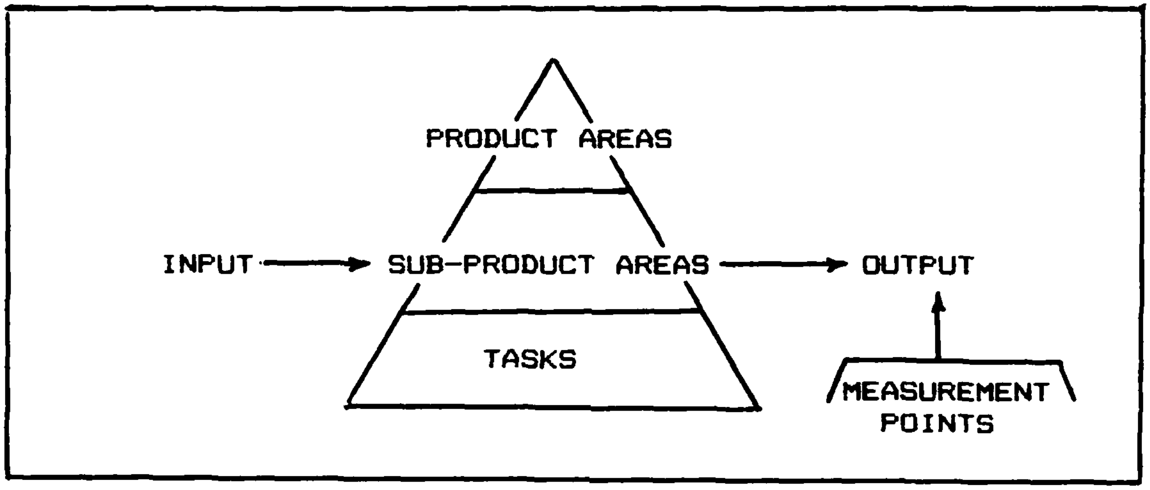


Figure 5. Measurement Process.

The beauty of this approach is summarized below.

> Output/input measurement aligned by product area eliminates the traditional impasse faced by AFCE. Attempts to measure productivity have, by necessity, been process or symptom oriented (backlog counts, availability rates, lag times, etc.). Product oriented measurement (output/input) permits true productivity measurement [44:27].

Furthermore, productivity measurement from a product orientation allows AFCE to become more competitive with prospective contracting out efforts and more responsive in predicting performance to installation commanders and customers (44:79).

Summary

This chapter reviewed the literature on three areas of productivity: 1) background on productivity, (2) productivity in the Department of Defense, and (3) productivity in USAF Real Property Maintenance.

Productivity is a concept. It was defined as the degree specific goals are achieved (effectiveness) and level of effort expended (efficiency) in that achievement. Applying this definition, however, presented particular problems to not-for-profit organizations, such as USAF Civil Engineering, because there is no overall measure of productivity comparable to the profit measure. Consequently, not-for-profit organizations typically use indirect measures to quantify their output.

The Department of Defense is committed to productivity enhancement. The foundation for DOD's productivity program is DOD Directive 5010.31 and DOD Instruction 5010.34. These documents implement and establish the program's goals. More recently, OMB Circular A-76 has prompted DOD agencies to perform efficiency reviews of all commercial activities. The Air Force Civil Engineering review effort is known as Project IMAGE.

Air Force Real Property Maintenance currently assesses productivity by using a multitude of indicators and relative measures. These methods, however, do not allow for a quantitative measure of the work output. The present emphasis is on identifying civil engineering product areas and the corresponding quantitative measure for those areas.

III. A Productivity Indicator to Improve Air Force Civil Engineering

Overview

This chapter will present a productivity indicator to improve Air Force Civil Engineering performance. First, the civil engineering mission, scope of responsibility, and structure will be discussed. Since the productivity indicator will be applied to the Operations Branch, specific attention will be focused on this area of the organization. Second, the concept and components of the productivity indicator will be presented. Third, since Engineered Performance Standards form the commonality, or foundation, in applying the productivity indicator, the final portion of this chapter will review the development and use of the standards.

Air Force Civil Engineering

The mission of Air Force Civil Engineering,

> ...is to provide the necessary assets and skilled personnel to prepare and sustain global installations as stationary platforms for the projection of aerospace power in peace and war [38:2].

From this mission statement eight product areas were identified (44:III; 45:IMC83-2).

1. Ensure readiness.
2. Provide real property.
3. Sustain real property.

4. Provide utilities.

5. Establish physical environment

6. Provide fire protection.

7. Provide non-real property services.

8. Provide technical and management services.

The mission statement and accompanying eight product areas outline a vast responsibility for civil engineering managers. The extent of this responsibility and some of the resources used to manage this task are summarized by Major Patrick M. Coullahan, Chief, Project IMAGE Team.

> The Air Force Civil Engineering (AFCE) community has this responsibility at 135 major air bases and 2934 global installations with a replacement value of $115 billion. AFCE operates and maintains 66,000 buildings and 147,000 Military Family Housing units--a total of 727 million square feet of buildings. Additionally, we have the responsibility for O&[[Operations and Maintenance] of 231 million square yards of pavements and 11 million acres of land. Our annual budget exceeds $6 billion. Our facilities have a 29 year average age. To do the AFCE job, we employ 60,000 military and civil engineering personnel and have contracted out over 17,500 man-years of effort [10:1].

The person responsible for managing the installation level civil engineering effort is the Base Civil Engineer. He "plans directs, supervises, and coordinates all civil engineer activities" (38:9). In performing his duties, the Base Civil Engineer is faced daily with many constraints. Four major constraints are (4:1-2):

1. Public Law.

2. Regulations.

3. Base and Wing Commanders.

4. Higher Headquarters.

These constraints while providing guidance, at the same time reduce the flexibility of the Base Civil Engineer. Also, at times there are conflicts among the constraints. For instance, the Wing Commander may desire the installation of certain equipment in a facility, while at the same time, public law or regulation prevents such action. Nevertheless, the guidance does serve as a framework to guide the organization.

The civil engineering organization is a "highly centralized organization, organized along functional lines" (31:2). The organization is typically composed of three major branches: Operations, Engineering and Environmental Planning, and Fire Protection. The other branches of the organizations serve as staff assistance to the Base Civil Engineer. *Figure 6 shows the* Base Civil Engineer Organization Chart as adapted from AFR 85-10, Operation and Maintenance of Real Property (38:19).

The largest branch in the civil engineering organization is usually the Operations Branch. The branch's resources are vast. Consider, it typically spends 50 percent of the base's operation and maintenance funds (7:1) and has the most varied vehicle feet on base. The scope of the branch's responsibility can be seen by reviewing two duties of the Chief, Operations Branch.

> Directs and controls the identification, planning, and accomplishment of all work selected for utility operations programs and the recurring work programs.
>
> Manages all activities that identify, receive, approve, authorize, direct, and control work accomplished inservice [45:12].

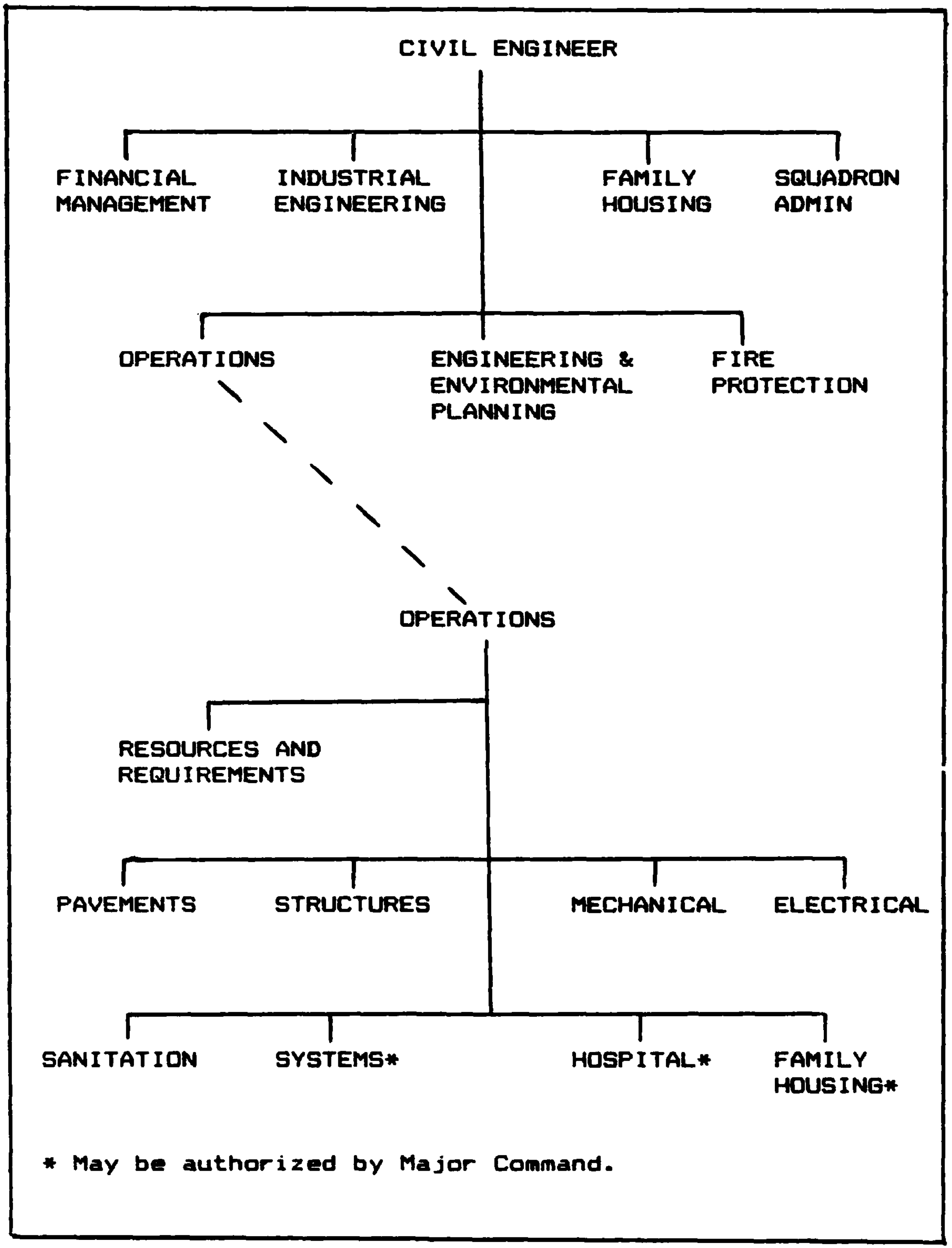


Figure 6. Base Civil Engineer Organizational Chart.

The Productivity Indicator

This thesis examines one aspect of a productivity concept developed by the Project IMAGE Team to evaluate the civil engineering product area "sustain real property".

The product area "sustain real property" is composed of three overlapping component areas, shown in figure 7 (12:-).

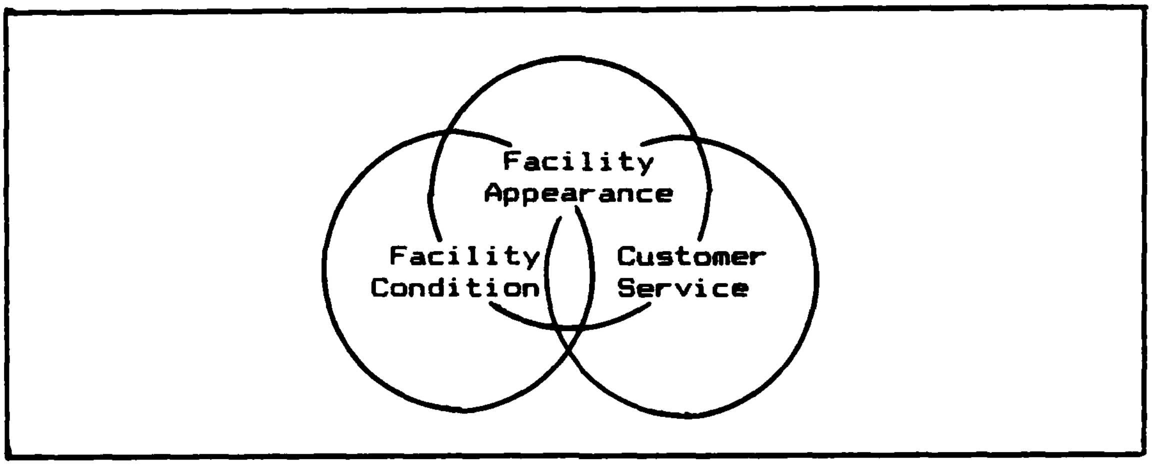


Figure 7. Components of Sustaining Real Property.

The Project IMAGE Team has developed and proposed tentative measurement techniques for each component (40:6-15).

1. Facility Condition. Use condition indexes to evaluate the condition of base facilities. Some condition indexes already exist such as the Pavement Condition Index for base roads and runways.

2. Facility Appearance. Facility appearance is to be evaluated by distributing surveys to the base populace on a recurring basis. The audience would be targeted to personnel such as senior commanders, base housing occupants, maintenance personnel, and dormitory residents. An analysis of the surveys should provide a good measure of this component.

3. Customer Service. This area will be evaluated by applying an indicator to measure the work output of the organization. The indicator will be explained in more detail later.

This thesis will further develop and test the customer service productivity indicator contained in Appendix A. However, the focus of the thesis will be to apply the indicator to the Operations Branch and not the entire organization. A presentation of the indicator now follows.

Symbolically, the productivity indicator may be expressed as,

$$WPC = E \times T \times V$$

where

E = Standard work hours completed. This is the total labor hour estimate of work for the job. It can either be the Engineered Performance Standard, planner's estimate, or a combination of both.

T = Timeliness/quality factor. This is a combination of two factors: timeliness, as determined by how quickly the work is completed; and quality, as determined by the number of times the work has to be re-done, if any.

V = Value factor. This factor is obtained from a matrix considering urgency of the task and type of facility.

WPC = Weighted Production Count. This is the factored result, where a higher value indicates higher productivity. This value is a relative measure that can be used for comparison from one time period to a similar time period.

In application, the productivity indicator will be used on each [craft] job completed by Operations Branch personnel to yield a weighted production count for that job. In turn,

the weighted production count for all jobs completed in a designated time period can be tallied. Weighted production counts for the period can be grouped by shop, section, and finally, the branch.

In concept, the indicator accounts for the key aspects of a job.

1. Quality. The indicator directly accounts for quality by introducing a reduction factor if the work is repeated within a specified time. There is also an indirect link to quality. The labor hour estimate is the calculated amount of time necessary for the work to be completed to a specified craft quality. Excess time needed to complete the job is not allocated toward the weighted production count, and reduces the available time to complete other jobs. Hence, emphasis will be placed on completing the job correctly and within the allotted labor hour estimate the first time, and thus, available time is directed toward maximizing production.

2. Timeliness. A reduction factor is introduced if the job is not completed within a prescribed time. The prescribed time is based on the type work, e.g. emergency, urgent, etc.

3. Urgency of Work. The type of work is directly correlated to the urgency. For example, an emergency job order is the highest urgency of work in the civil engineering system. In turn, type of work is linked to the reduction factors. See Chapter V, Results, for further clarification.

4. Difficulty of Work. Difficulty of work is accounted for in the labor hour estimate. More difficult jobs include additional hours to compensate for the difficulty.

5. Relative Value to the Mission. Value to the mission is directly correlated to the type of work required and facility involved. For instance, emergency work to a communications facility will have a higher value to the mission than routine work on an administrative facility.

6. Quantity. Quantity is reflected in the calculated weighted production count. The higher the production count, the more timely, quality, and mission related work was done.

In Chapter II efficiency and effectiveness were defined as the components of productivity. Contrasting these components against the six aspects of the indicator just presented, we see a connection. Quantity and timeliness provide some measure of efficiency. And, quality, urgency, difficulty, and value to mission provide a measure of effectiveness. Thus, the productivity indicator contains the essential ingredients to assess productivity.

What are Engineered Performance Standards?

Engineered Performance Standards (EPS) form the foundation for estimating in-house civil engineering work. Their use is to provide better planning and programming of work.

EPS Defined. Engineered Performance Standards are,

> ...the average time necessary for a qualified worker, working at a normal pace, under capable supervision and experiencing normal delays, to perform a defined amount of work, of a specified quality, while following acceptable trade methods [41:9].

The terms "normal," "average," and "acceptable" are subjective and have different meanings to different people. However, the standards themselves are based on conditions which have proven to represent a norm (35:2).

Background. The history of work standards started in 1955 when DOD requested the military services to develop work standards for Real Property Maintenance Activities (46:-). In response, Air Force Civil Engineering developed bench mark standards which were included in AFM 85-1, Resources and Work Force Management (46:3). At the same time, the Navy took a more exact approach by adopting industrial engineering techniques, which later formed the framework for the concept of developing standards for maintenance work (35:1; 46:3). In 1968 the DOD conducted a tri-service test to determine which service had the best standards and which should be adopted DOD-wide (19:19; 46:3). Based on the results of this test, the Navy was designated the lead agency and their standards directed for use by DOD Real Property Maintenance activities (19:19). However, subsequent Navy budget cuts delayed further EPS development. The Navy budget cuts coupled with lack of command interest delayed full acceptance of EPS within DOD (19:19; 35:1).

In the mid-1970's several factors placed renewed emphasis on EPS. First, DOD Instruction 5010.34 addressing productivity enhancement, measurement, evaluation and operation guidelines, and reporting instructions was published in August 1975. This instruction outlined the need to achieve optimum productivity growth by employing

industrial engineering techniques to improve labor performance methods and standards (48:1-2). The document also amplified on the subject of methods and standards by stating,

> Development and use of appropriate types and levels of labor performance standards can contribute significantly to productivity improvements....Detailed labor performance standards (covering individual tasks, jobs, and operations) should be developed for use at work center and field operating levels in workload planning and control and balancing of resources and necessary workloads [48:encl 1 page1].

Second, Perry J. Fliakas, then Deputy Assistant Secretary of Defense for Installations and Housing, issued a letter in July 1976 which re-emphasized DOD Instruction 5010.34 and requested the Navy EPS manuals be updated and the cost for issuance of this data be shared equally among the services (15:1). Third, on 19 August 1976 the Government Accounting Office (GAO) published a report to Congress, titled "Major Cost Savings can be Achieved by Real Property Management," which stated in part, the Secretary of Defense should require improved standards coverage (16:1). Further, the GAO report determined,

> ...the proper application of performance standards (in particular the Navy EPS) could significantly increase productivity in real property maintenance and recommended that the Navy EPS program be revitalized [19:19].

The GAO report went on to recommend: (1) an increase in the jobs covered by performance standards, (2) quality improvement of the Navy EPS, and (3) "summary information based on EPS be more widely used in Real Property Maintenance Activities management and budget decisions" (46:-).

The services' reaction to the renewed emphasis on using EPS still was slow. In fact, testifying before a House of Representatives Subcommittee on defense appropriation in 1978, Major General William Gilbert, then Director of Engineering and Services, stated usage of EPS is expected to only reach 55% by the end of fiscal 1978 (49:213). Though the Navy and Army reported higher EPS use to the committee (49:214), Congress was not satisfied with the services' level of usage. Therefore, in fiscal 1979 Congress appropriated an additional $500,000 and 16 civilian positions to ensure improved use of the standards (14:2).

As a result of congressional interest, and further DOD initiatives such as the establishment of the Naval Facilities Industrial Engineer Center and increased training for work planners/estimators (14:1; 29:1), EPS management and usage in real property maintenance has improved.

EPS Development. EPS was developed by Industrial Engineers and Technicians observing maintenance workers and measuring their effort through the application of proven industrial engineering techniques (41:19). The methods time measurement is one technique.

> EPS average times, for most of the craft data, are developed by methods time measurement (MTM). MTM is a predetermined time system where work content of a task is subdivided into...elements. A smaller predetermined time value, called a TMU (time measurement unit), is assigned to each motion of the element. These are aggregated together to form the core craft time and recorded in the EPS handbooks [19:18-19].

Besides MTM, two other industrial engineering techniques are used in EPS development: time studies and work sampling

(41:46). Time study involves measuring work, normally with a stopwatch, and is used in EPS development to measure time elements not fully under the control of the worker, such as machine time (41:46). Work sampling, on the other hand, is used in EPS development to determine percentages of work or delays as a part of the total time expended (41:46). This technique is accomplished by observation of the worker on the job.

Through the use of the MTM, time study, and work sampling techniques, the general and craft data necessary to accomplish a job can be computed to yield a maintenance work standard. Figure 8 shows the components of the general data related to a job and some typical examples associated with each component. From the figure,

CRAFT DATA = TOTAL OF TASK TIMES

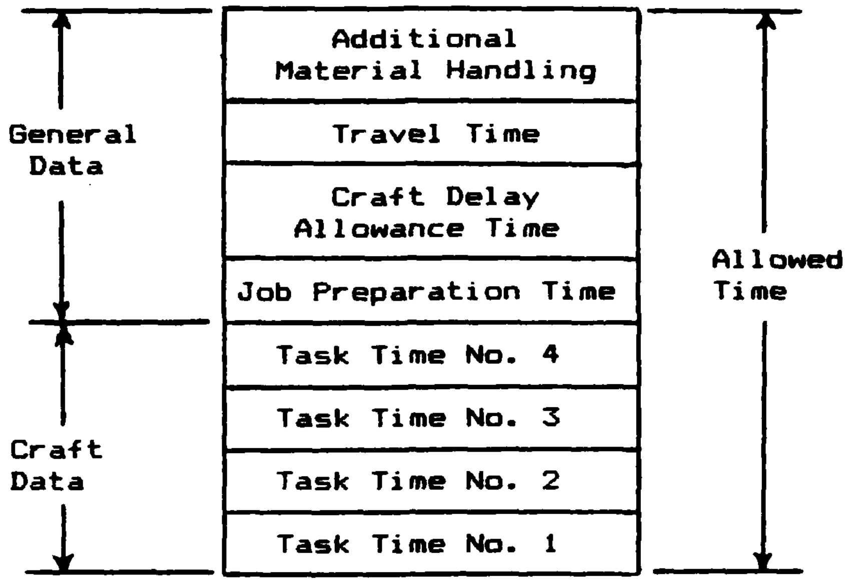
GENERAL DATA = JOB PREPARATION, TRAVEL, DELAY ALLOWANCES, ADDITIONAL MATERIAL HANDLING

ALLOWED TIME = CRAFT DATA + GENERAL DATA

EPS Benefits. Engineered performance standards provide many benefits to planning and management of engineering work (35:1).

1. Improved Task assessment. EPS allows the planner to break down the task and apply detailed craft time values.

2. Realistic Labor Costs. By applying accurate task times on a consistent basis, the planner is able to realistic determine labor costs.



1. Additional Material Handling time covers:

   a. Loading materials on truck from storage area.
   b. Unloading materials from truck at job site.
   c. Moving materials from storage area at job site to immediate work area.
   d. Moving debris from work area to truck/dumpster.

2. Travel Time covers:

   a. One round trip between shop and job site.
   b. A short wait for transportation.
   c. Loading and unloading had carrier tool box.
   d. Traveling to unloading point.
   e. Walking an average distance to job site.

3. Craft Allowance time covers:

   a. Unavoidable delays-broken tool, defective part.
   b. Planning-study job site, blueprint.
   c. Balancing delay-one craftsman waits for another.
   d. Personal-smoke; coffee; rests.

4. Job Preparation covers time for:

   a. Receiving Job assignment and/or instructions.
   b. Planning equipment requirements.
   c. Getting tools together at beginning of day.
   d. Cleaning tools and putting them away.
   e. Filling out tool chit.

Figure 8. Building Blocks of a Work Standard.

3. Better Maintenance Management. EPS allows management a standard to compare actual work durations.

4. Improved Job Planning. Knowing task times allows easy phasing of complex, multi-skilled work.

5. Better Labor Performance. EPS provides the worker a justified standard to meet. As in goal setting, experience has shown the worker will try to meet the standard.

6. Improved Backlog Management. EPS provides management with a consistent and accurate backlog.

7. Uniformly Transferable Data. EPSs for many tasks have been developed, and the data can be applied to similar tasks at different locations.

EPS Validity and Scope. When applied to EPS, validity refers to the quality of the estimate (41:137).

> For work control and productivity purposes an EPS estimated job is considered valid when at least 75 percent of its manhours are estimated using EPS [41:137].

In AFCE, Engineered Performance Standards are primarily applied to work orders, job orders, and recurring work (19:18). EPS application is not required for emergency and urgent work, utility operations, and hours for contracted shops (45:10).

Air Force EPS Utilization. EPS utilization is the extent EPS is used to estimate real property maintenance work (19:19). To measure EPS utilization, the percentage of EPS estimated hours to total direct actual hours is computed for three categories of work: work orders, job orders, and recurring work (15:-). Then, a weighted average of the three categories is obtained to yield an EPS utilization rate.

Table 1 summarizes the results obtained from civil engineering units in Alaska, Hawaii, and CONUS by the Air Force Engineering and Services Center (AFESC) EPS Utilization Teams for fiscal years 1981-84 (36:-).

Though Table I reveals a steady increase of EPS use by AFCE units, the percent utilization is just an average of the bases visited that year and may not represent a true AFCE wide average. Nevertheless, the trend of bases visited does indicate an increase of EPS use. In fact, as of 8 January 1985 EPS use for AFCE was stated as 64.7 percent (20:-).

TABLE I

AFCE EPS UTILIZATION FOR FISCAL YEARS 1981-84

Fiscal Year	Average Weighted EPS Utilization (%)	Number of Bases Visited
1981	12.5	23*
1982	17.5	39
1983	31.8	45
1984	63.4	31

*Five bases evaluated by the Major Command instead of AFESC.

Summary

This chapter discussed the Air Force Civil Engineering organization, the Project IMAGE productivity indicator for customer service, and Engineered Performance Standards.

Air Force Civil Engineering is big business. It is responsible for mission support at over 3000 global installations. Eight product areas, ranging from ensuring

readiness to fire protection, comprise this mission support. The in-house responsibility of product area "sustain real property" rests with the Operations Branch. To assess performance in this product area, the Project IMAGE Team has proposed an output measurement.

"Sustain real property" is comprised of three overlapping areas: facility condition, facility appearance, and customer service. The productivity indicator to assess customer service relies on factoring the planned labor hour estimate to yield a relative productivity measure--a weighted production count. The method considers quantity, timeliness, job difficulty, mission impact, quality, and work urgency. The planned labor estimates are determined by relating to the job Engineered Performance Standards, planner's estimate, or a combination of both.

Engineered Performance Standards are the average time needed for a qualified worker to satisfactorily do the job. EPSs provide many benefits to planning and management of engineering work. These benefits include improved task assessment, job planning, and performance.

IV. Methodology

Overview

This chapter describes the approach and methodology used to answer the investigative questions posed in Chapter 1:

1. What further factor development is needed to use the productivity indicator?

2. What computer software is needed to employ the productivity indicator?

3. How do the indicator's computed results generally compare to manager perceptions of productivity?

In answering these three investigative questions, the thesis--to test and determine practical usefulness of the productivity indicator to Civil Engineering Operations Branches--can also be answered.

The first section of this chapter specifies the bounds of the research effort. Later sections of the chapter describe the approach used to employ the productivity index to the data gathered from the 2750th Civil Engineering Squadron.

Research Bounds

In his article, "Critical Questions in Assessing Organizational Effectiveness," Cameron (8:73-78) concluded that six questions must be addressed before any evaluation of an organization can be made: (1) what domains of activity will be the focus of the evaluation, (2) whose perspective or

point of view will be used, (3) what level of analysis will be used, (4) what time frame will be employed, (5) what type of data will be used, and (6) what referent will be employed? Though Cameron posed these questions with respect to effectiveness, Chapter II of this thesis defined productivity as the multiplicative product of effectiveness and efficiency. As such, effectiveness, efficiency, and productivity are intimately related, and in answering the critical questions made by Cameron the research bounds for this thesis can also be set.

Domain of Activity. According to Cameron, most organizations function in an assortment of domains (8:74). As was discussed in Chapter III, civil engineering's mission statement yielded eight product areas, which may be construed as domains of activity. In addition, civil engineering has other domains: (1) an external domain emphasizing community service by its members, (2) an employee domain emphasizing professional/career development and training, and employee health, morale, and satisfaction.

The focus of this thesis will be on the domain/product area sustain real property. Specifically, sustain real property is composed of three overlapping component areas: (1) facility condition, (2) facility appearance, and (3) customer service. Customer service, as was defined in Chapter I, is the specific focus of this thesis.

Perspective or Point of View. The second question refers to the perspective or view point that will be used to

guide the research. Civil engineering is a customer oriented organization. On each installation there are many customers competing for civil engineering resources. As was discussed in Chapter III, the centralized structure and bureaucratic nature of civil engineering constrains managers to balance the needs of the customer against the requirements of the mission. As a result, this study will assess productivity both from a customer and organizational perspective. That is, productivity will be measured as level of service to the customer (Operations Branch's direct work output). But, the service will be evaluated considering the mission requirements and priority system.

Level of Analysis. According to Mcknight and Parker (26:46), effectiveness [like productivity] of a structured organization can be evaluated at three levels: (1) the individual, (2) the shop or branch level, and (3) the overall organization. As was mentioned in Chapter I, the focus of this thesis was on the branch level. Actually, analysis will begin at the shop level and then use a "building block" approach. The shop level productivity measures will be combined to yield an overall branch measure.

Time Frame Employed. The time frame employed by this thesis is not important. As was discussed under "scope and limitations" of Chapter I, this thesis is a first step to demonstrate actual application of the concept. As such, the emphasis is on developing the mechanics for employment of the productivity indicator, as opposed to uncovering productivity trends or comparing productivity among units. For this

thesis time periods of one month will be analyzed. One month was chosen because it represents the typical frequency used by civil engineering managers to analyze the overall progress of their sections. While many civil engineering indicators are generated weekly, their focus is of a specific nature. On the other hand, the indicator under study is more general in that it provides a total production count for the branch.

Type of Data Used. As was stated in Chapter II, productivity is an elusive term having many different meanings. Though a definition for productivity was established, purely objective or subjective data cannot be used. Rather, a combination of objective and subjective data must be used. For instance, measures of efficiency such as number of job orders complete is objective. Conversely, assessing quality of work or importance of facility is subjective. Thus, the data collected for this thesis is both objective and subjective.

Referent Employed. The last question relates to the manner in which the productivity indicator will be used. Cameron discusses five categories of referents (8:78).

1. Comparative Evaluation compares the indicators from one organization to the same or similar indicators of another organization.

2. Normative Evaluation compares the organization's performance against a standard or an ideal performance.

3. Goal-Centered Evaluation compares the organization's performance against a stated goal of the organization.

4. Improvement Evaluation compares the organization's performance against its past performance on the same indicators. Or, improvement can be assessed by comparing effectiveness relative to a competitor.

5. Trait Evaluation compares the organization's characteristics against a specific list of desirable traits, which have been described by a group of "experts."

As developed by the Project IMAGE Team, the productivity indicator is a relative measure designed to compare results from one time period to another. Therefore, improvement evaluation was the referent chosen for this study.

Population of Concern

The 2750th Civil Engineering Squadron Operations Branch was chosen as the organization to test the productivity indicator. There were two main reasons for this choice. First, the Operations Branch had an in-place working Work Information Management System (WIMS). A flexible computer system such as WIMS was necessary if the required data manipulations were to be made. Also, the Project IMAGE Team based their development of the productivity indicator for use on the WIMS. Second, since this thesis was a first attempt at employing the indicator, an organization near the AFIT School of Systems and Logistics, was necessary. Frequent interaction between the organization and author was needed.

The 2750th Civil Engineering Operations Branch is one of the largest organizations of its kind in the Air Force. To perform the mission outlined in Chapter I it employs approximately 930 personnel, spends about $50 million (projected operations and maintenance budget for fiscal year 1985), and operates about 200 vehicles. Also, it is responsible for over 8000 acres of land and 2000 facilities.

Methodology

Investigative questions one and two were answered using the following steps.

1. Collect Data. The indicator was tested on the School of Civil Engineering's WIMS computer; therefore, needed data had to be identified and transfered from the Operations Branch to the school. Chapter V, Results and Analysis, describes the data collected.

2. Determine Factors. As was described in Chapter III, the productivity indicator processes standard labor hour work estimates against two factors: timeliness/quality and value. These factors were determined using Air Force regulations, Project IMAGE guidelines, and input from the Operations Branch. Chapter V better describes this process and presents the factors.

3. Develop Computer Software. Write a computer program to employ the indicator. The WIMS at the School of Civil Engineering allows the use of several computer languages. The computer language BASIC was chosen. Chapter V discusses development of the program.

4. Test Software. This step involves debugging of syntax and logic errors. Syntax errors were easily found by the WIMS BASIC compiler. Logic errors were eliminated by systematically testing each possible "avenue" the program could take. Further, the WIMS Report Utility was used to check the program's "read" capability.

To answer the third investigative question, typical information used by managers to assess productivity was gathered. Using this information, managers were asked to evaluate their customer service on a scale of 1 (unsatisfactory) to 5 (outstanding). The factors used for the evaluation and the results are presented in Chapter V.

Summary

This chapter described the research bounds and methodology used to answer the investigative questions posed in Chapter I.

The research bounds were established by answering the six questions posed by Cameron in his article, "Critical Questions in Assessing Organizational Effectiveness."

1. Domain: The sustain real property product area of civil engineering. Specifically, the customer service aspect.

2. Perspective: The civil engineering organization and customer.

3. Analysis Level: Branch level.

4. Time Frame: Month by month analysis.

5. Type of Data: Objective and Subjective Data.

6. Referent: Improvement evaluation.

The methodology involves 1) collect data, 2) determine applicable factors for the productivity indicator equation, 3) write computer program, and 4) test computer program. Essentially, this section outlined the procedure.

An indepth explanation of the procedures is provided in Chapter V, Results and Analysis.

V. Results and Analysis

Overview

This chapter will discuss and analyze the research results. Specifically, the first part of the chapter will discuss data collection and development of the factors needed for the indicator. Later sections will discuss program development and output analysis.

Data Collection

When applied to the Operations Branch, the definition of Customer Service encompasses the branch's direct work output. According to AFR 85-1, Resources and Work Force Management, direct work output for the Operations Branch is categorized as utility operations, recurring work, job orders, and work orders (45:101).

Utility Operations involves providing electricity, water, natural gas, and/or steam to base facilities. Output for this work is measured in BTUs, kilowatts, etc. Operations Branch manpower for utility operations is usually determined by safety standards and the equipment used to provide the service and not by the level of output. For example, a utility output of 15000 kilowatts requires no less manpower than an output of 20000 kilowatts. In terms of level of service, the customer does not perceive the extra 5000 kilowatts as an increase in service. Instead, it is viewed as a continuance of service. For the customer,

utilities are typically viewed as either available or not. For civil engineering, a relatively unchanging work force is needed to provide utilities. Further, since the indicator is a relative measure, there will be no impact (from one month to the next) on the indicator due to utility operations. For these reasons, data on utility operations is not needed for the productivity indicator, and therefore, was not collected.

About twenty-five percent of the Operations Branch's direct work output is in the form of recurring work. As a result, recurring work should be evaluated by the productivity indicator. However, the 2750th Civil Engineering Operations Branch currently does not have the capability to process recurring work on their WIMS. Consequently, application of the productivity indicator to recurring work could not be done. The 2854th Civil Engineering Squadron at Tinker AFB, however, does have the capability to process recurring work. Recurring work control files (details what recurring work information will be stored on WIMS) were obtained from them. Later, this chapter will discuss the potential to include recurring work in the computer program.

Job orders and work orders constitute the major portion of direct work by the Operations Branch. Therefore, job order and work order data were collected. The files collected were labeled MJOBH, MJOBH1, and MJOB for job orders; and MWOJOBH and MWOJOB for work orders. The data spanned the period October 1984 to April 1985.

Two other data files were collected. The real property file, label RPD, was obtained. Later in this chapter it will be shown how each base facility was priority coded and this information used to process job orders and work orders. The other file obtained, labeled EPSPHASE, contains the labor estimate (EPS, planner's, or both) for work orders. In the computer program this file is used to determine the standard work estimate for work orders.

Factor Development

This section answers the first investigative question: What further factor development is needed to use the productivity indicator?

As was presented in Chapter III, the productivity indicator uses two factors: value and timeliness/quality. For reasons explained later, the timeliness/quality factor will become two separate factors.

Value Factor. The urgency and location of the job are combined in a matrix to determine the value factor.

1. Job Urgency. Urgency of the job can be readily identified using the civil engineering system. The system classifies each job according to the scope of work and urgency. First, smaller, less detailed jobs are placed on job orders and larger, more complex jobs on work orders (45:40,55). Then, within job and work orders there is a priority used to designate urgency of work. For instance, there is emergency, urgent and routine priorities within job orders; and priority I through IV for work orders. The civil

engineering system will be used by the indicator to classify urgency of work.

The urgency, as proposed, had six categories (see Appendix A). The last two categories, however, pertain to contract work and are not applicable here since this thesis focuses on the work output of the Operations Branch (in-house). Also, as proposed, two categories were allocated to work orders: Maintenance & Repair and Minor Construction. This approach does not fully identify urgency within work orders. A system to prioritize work orders from I to IV is explained in AFR 85-1, Resources and Work Force Management.

> Priority I--Mission. Work in direct support of the mission that if not done would reduce operational effectiveness.
>
> Priority II--Safeguard Life and Property. Work needed to give adequate security to areas subject to compromise; to eliminate health, fire, or safety hazards; or to protect valuable property or equipment. Also, include energy conservation work.
>
> Priority III--Support. Work which supports the mission or prevents a breakdown of essential operating or houskeeping function.
>
> Priority IV--Necessary. Not qualifying for higher priority.
>
> [45:32]

Work order priorities directly relate to job urgency. They provide the impetus for civil engineering actions, more so than the designation Maintenance & Repair or Minor Construction. As a result, work order priorities were included in the determination of job urgency.

Table II presents the categories of urgency. Since the categories were adapted from existing civil engineering classifications of work, they are called work categuries.

TABLE II

WORK CATEGORIES

Category	Description
A	Emergency Job Orders
B	Urgent Job Orders
C	Routine, SMART, and Minor Construction Job Orders
D	Priority I & II Work Orders
E	Priority III & IV Maintenance & Repair Work Orders
F	Priority III & IV Minor Construction Work Orders

For priority III and IV work orders with no work class (e.g. not designated Maintenance & Repair or Minor Construction) a work category of "E" is assigned. For example, a priority III or IV demolition job would be classified as work category "E."

The work categories, as presented, are those used in this study. They can, however, be modified to meet local mission requirements. The Base Civil Engineer may elect to further categorize the work, or he can combine categories.

2. Facility Categories. In addition to job urgency, the location of the job is needed to determine the value factor. The underlying concept is: work on facilities directly affecting mission capability are of more value than work on facilities indirectly affecting the mission. Therefore, it is important to identify the job location.

Civil engineering uses a six digit category code to categorizes each facility according to its function. Use

of this system in the value matrix would be ideal. However, the majority of Wright-Patterson AFB facilities have more than one category code. For instance, an aircraft maintenance facility may have maintenance, administration, and training areas all located in one building. Each area would have a separate and unique category code. Also, the fire protection and air conditioning/heating systems will have different category codes. Again, it is typical for most facilities to have more than one category code.

Currently, the civil engineering work documentation system for job and work orders does not associate category codes with the job location. Further, there is no current way to systematically (i.e. using the WIMS) associate the job site with a category code. Although the system can not associate category codes to the job site, it does track the facility number of the job.

Using facility numbers, general categories of facilities were grouped. For example, facilities having the highest mission impact were one group, while all facilities providing housing were another group. For this thesis, each base facility was evaluated and its most prevalent function was used to categorize the facility. Although this approach is a compromise from that of using category codes, it does offer a means to relate job site to mission impact. The compromise occurs when a top priority function is within a much larger lower priority facility. For instance, the Headquarters Air Force Logistics Command building primary contains administrative functions and was classified in the

administrative category. But, it also contains a high priority command, control, and communications function. As processed in this thesis, the work performed on the high priority function received the same value as the work performed in the administrative area of the building.

Table III presents the facility categories used in this thesis. For work that had no associated facility number, a facility category code of "D" was assigned.

TABLE III

FACILITY CATEGORIES

Category	General Description of Facilities
A	Communications, Navigation Aids, Airfield Lighting
B	Airfield Pavements, Primary Electric Distribution, and Liquid fuel Dispensing
C	Maintenance, Fuel Storage, Hospital, Water Distribution & Treatment, Heat & Natural Gas Distribution, Ammunition Storage, and Test & Research
D	Administration, Training, Roads, and General Storage
E	Housing (Base, Dormitory, and Temporary/Visiting)
F	Morale, Welfare & Recreation, and Land

For the Real Property data file (label RPD) received from the 2750th Civil Engineering Squadron, the related control file was modified to allow entry of the characters "A, B, C, D, E or F" in an existing data column. Later, the facility category of each base facility was determined and a corresponding character was entered in the data file. This was the only modification made to any data file.

3. Value Factor Matrix. Using the categories established for work and facilities a matrix was constructed. Figure 9 displays the Value Factor Matrix used in this study. Generally, the upper left factors are of higher value than those in the lower right portion of the matrix. The rationale used in determining the factors basically involved drawing relative comparisons between matrix blocks. To demonstrate, work categories can be comparatively ranked from a high priority to low: (1) emergency job orders, (2) urgent job orders and priority I & II work orders, (3) routine job orders, and (4) priority III & IV maintenance & repair and minor construction. For facility categories, higher valued facilities are to the left of the matrix. The exception is housing, comparatively ranked higher than category "D."

WORK CATEGORY	FACILITY CATEGORY A	B	C	D	E	F
A	1.0	.97	.95	.90	.90	.88
B	.95	.95	.90	.85	.90	.80
C	.92	.87	.86	.80	.85	.75
D	.94	.90	.90	.85	.85	.78
E	.90	.86	.85	.75	.80	.70
F	.90	.85	.85	.75	.80	.70

Figure 9. Matrix to Determine Value Factor.

As was stated in Chapter I, the objective of this thesis was to further develop and demonstrate application of the productivity indicator. Consequently, emphasis was placed on developing the framework for the value matrix and not on the actual numbers it contained. In fact, the numbers may not be static from one base to another. For example, an old base may place more value on maintenance work, while another base undergoing a lot of renovation may emphasis construction as being important to the mission.

Quality Factor. As initially proposed, quality would be assessed by determining the number of repeat jobs. A repeat job, as defined by the Project IMAGE Team, is one that had to be redone in seven days. This approach was to be combined with timeliness of the job completion to yield an overall factor. Civil engineering records, however, do not contain detailed enough information to determine whether one job is a duplicate of another. For instance, a job order on Friday requiring "repair of an inoperative air conditioner at building XXXX," can not always be considered the re-work of another job order with the same job description completed the previous Monday. The air conditioner could have required different repairs, yet the job descriptions were almost identical. This lack of detailed information on each specific job makes applying the proposed quality factor infeasible. Currently there is no good system to track repeat work.

Another more direct approach to evaluate job quality is by actual job inspection. While inspection of every job is not feasible due to manpower requirements, random spot inspections could provide an overall job quality factor for the Branch.

The 2750th Civil Engineering Operations Branch has a Quality Assistance Section tasked to monitor and document the branch's job quality. The squadron's Quality Assistance Program is established and implemented by CES Operating Instruction 85-7 (43:-). According to the instruction, the program "is designed to provide an efficient, flexible means of assuring the quality of work" (43:1). The instruction further states,

> The Quality Assistance Program is designed to ensure our customers receive quality service, to maintain acceptable quality work standards, and to monitor the level and quality of work performed by Civil Engineering personnel [43:1].

To accomplish this objective,

> The Quality Assistance program manager will select, on a weekly basis, 5 to 10 percent, or other percentage as directed by th DEM [Operations Branch] Chief, of the job orders/work orders or recurring wo k tasks accomplished during that week and will rate the selected jobs... [43:1].

Each job inspected by the Quality Assistance Section is rated either outstanding, satisfactory, or unsatisfactory. Using the results, an assessment of the Operations Branch's work quality can be made.

For this thesis, the percentage of jobs inspected and rated satisfactory or higher was used as the quality factor. Using this approach, a quality factor can not be determined

for each job. In fact, the factor should only be applied to the entire branch. Since only 5 to 10 percent of the branch's jobs are evaluated, attempting to reduce the data could skew the factor. That is, the percentage of jobs rated satisfactory or higher is considered representative of job quality for the branch. However, the program makes no attempt to inspect a certain percentage of jobs for each shop or section, and similar application to these work levels would result in unreliable factors.

Table IV presents the inspection data obtained from the 2750th Civil Engineering Quality Assistance Section.

TABLE IV

OPERATIONS BRANCH JOB QUALITY FACTORS FOR OCT 84 - APR 85

Month	Jobs inspected	Number Sat or Higher	Quality Factor
Oct 84	334	317	.95
Nov 84	228	217	.95
Dec 84	157	156	.99
Jan 85	177	175	.99
Feb 85	53	52	.98
Mar 85	261	257	.98
Apr 85	359	344	.96

Timeliness Factor. Timeliness factors were determined using the Project IMAGE guidelines, AFR 85-1, and input from Operations Branch managers.

As was stated by the the Project IMAGE Team, timeliness should be assessed from the customer's viewpoint. That is,

timeliness should be evaluated from the time the request is received by civil engineering to the time of actual job completion. Evaluation of timeliness should not begin when the shop receives the work authorization or when material becomes available.

AFR 85-1, Resources and Work Force Management, identifies timeliness criteria for job orders.

(1) Emergency Job Orders. This is work that should be completed immediately, otherwise the mission or operational effectiveness will be reduced (45:49). While no specific completion time is stated, emergency job orders not completed within 48 hours of receipt will be brought to the attention of the Chief of Production Control (45:51). He then must take measures to ensure job completion at the earliest possible time (45:51).

(2) Urgent Job Orders. This work should be completed within five workdays (normally seven calendar days) (45:49).

(3) Routine Job Orders. This type of work should be completed within 30 calendar days after receipt of the work request or receipt of necessary material (45:40). As mentioned earlier, timeliness should be evaluated from the time the request is received and not from the time material becomes available. Consequently, job completion 30 calendar days after the requirement is identified will be the standard used in this thesis. Also, in the previous discussion about work categories, SMART and Minor Construction Job Orders were classified as routine. SMART

and Minor Construction Job Orders are similar to Routine Job Orders; therefore, no inconsistency will exist in applying the 30 day timeliness standard to these job orders.

There is little guidance for determining timeliness standards on work orders. AFR 85-1 provides no guidance in this area. The Air Force Civil Engineering and Services Management Evaluation Team evaluates a unit's work orders primary by assessing the backlog of work orders and civil engineering compliance in completing scheduled work orders (32:4,9). The backlog of work orders (typically expressed in months) is the time the Operations Branch would need to complete the work orders programmed for in-house accomplishment. This measure can broadly indicate when a work order will be completed. However, using this measure to determine timeliness of a specific work order would be difficult and imprecise. The compliance measure is a percentage of work orders completed to those scheduled and is an indicator of customer commitment and not timeliness.

Another area of guidance is from the Operations Branch. According to Captain Charles Huber, Chief of Requirements, and Mr Arlyn Johnson, Chief of Production Control, the branch's goal is to start 70% of all work orders within six months of receipt. They indicated the branch started approximately 60% of all work orders within six months of receipt in fiscal year 1984. This information was the underlying consideration for developing work order timeliness standards in the thesis.

From the preceding discussion, timeliness factors were developed.

(1) Emergency Job Orders. Table V displays the timeliness factors for Emergency Job Orders.

TABLE V

TIMELINESS FACTORS FOR EMERGENCY JOB ORDERS

Number of Days to Complete Work	Timeliness Factor
Less than 2	1.0
3	0.9
4	0.8
5	0.7
greater than 6	0.6

(2) Urgent and Routine Job Orders. For these categories the time needed to complete the job order was compared to the standard previously established. The result, a percentage, was then associated with a timeliness factor. Equation 1 shows the calculation for Urgent Job Orders and equation 2 for Routine Job Orders.

$$[(D - 7)/7] \times 100 = P \tag{1}$$

$$[(D - 30)/30] \times 100 = P \tag{2}$$

where D = Duration (Actual Completion date minus Job Receipt date)

P = Percentage

Table VI displays the timeliness factors for Urgent and Routine Job Orders.

TABLE VI

TIMELINESS FACTORS FOR URGENT AND ROUTINE JOB ORDERS

Percentage	Timeliness Factor
Less than or equal to 0	1.0
Greater than 0 and less than .25	.95
Greater than or equal to .25 and less than .50	.90
Greater than or equal to .50 and less than .75	.80
Greater than or equal to .75 and less than 1.0	.70
Greater than or equal to 1.0	.60

(3) Priority I & II Work Orders. Table VII displays the timeliness factors for these work orders.

TABLE VII

TIMELINESS FACTORS FOR PRIORITY I & II WORK ORDERS

Number of Days to Complete Work	Timeliness Factor
Less than 120	1.0
Greater than or equal to 120 and less than 150	.95
Greater than or equal to 150 and less than 180	.90
Greater than or equal to 180 and less than 210	.80
Greater than or equal to 210 and less than 240	.70
Greater than 240	.60

(3) Priority III & IV Work Orders. Table VIII displays the timeliness factors for these work orders.

TABLE VIII

TIMELINESS FACTORS FOR PRIORITY III & IV WORK ORDERS

Number of Days to Complete Work	Timeliness Factor
Less than 180 days	1.0
Greater than or equal to 180 and less than 240	.85
Greater than or equal to 240 and less than 330	.75
Greater than 330	.60

The timeliness factors for all work categories were discussed with Captain Huber and Mr Johnson. They related that the factors were satisfactory for application in their branch. Again, as with the other factors, the timeliness factors used in this study can be adjusted to meet local Base Civil Engineering needs.

Program Development

This section answers the second investigative question: What computer software is needed to employ the productivity indicator?

The computer program was developed and tested on the WIMS at the School of Civil Engineering, Air Force Institute of Technology. The program code is Wang VS BASIC (version 3.4.2). Appendix B contains the program.

In the most general nature, Figure 10 depicts a flowchart of the calculation process.

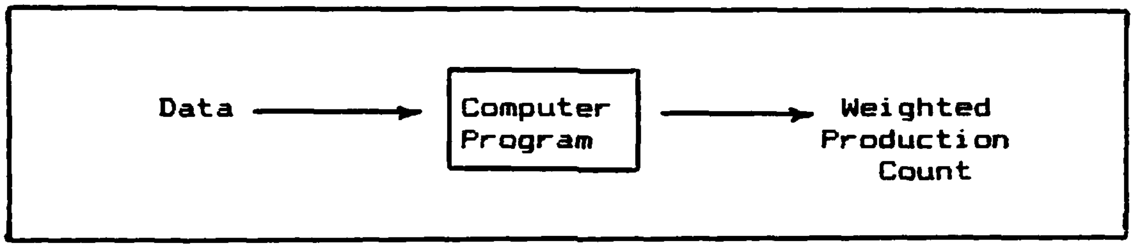


Figure 10. General Flowchart of the Calculation Process.

More specifically, the algorithm can be expanded to include the major blocks of the program. Figure 11 displays this information.

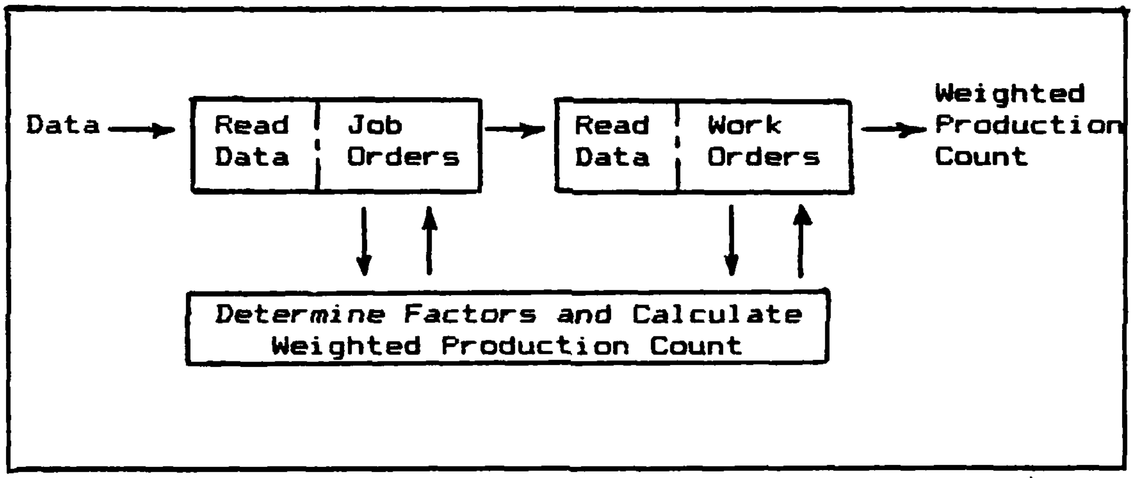


Figure 11. Flowchart of Program Weighted Production Count Calculation

<u>When Should the Work be Counted?</u> The objective of the productivity indicator is to assess relative productivity for a given time period. As was explained in Chapter III this is accomplished by evaluating each job completed in the time period. Many jobs, however, are not entirely accomplished in a specific time period. Instead, they span one or more time periods. Consequently, assessing productivity by counting jobs completed in a specific time period may not be entirely representative of the productivity for that period. For

example, consider a work order started on 1 March and completed on 1 April. If the time period evaluated is one month, then April would get "credit" for accomplishing this work. In reality, most of the work was done in March, and it would receive no "credit." An averaging effect does occur, however, between the beginning and end of a time period. That is, an inequity experienced at the beginning of a period would be minimized by a similar (but opposite) inequity occurring at the end. This inequity is more pronounced in work orders than job orders.

As was described earlier in this chapter, work orders generally involve larger, more complex jobs. Further, there is often little commonality between work orders. Because of this, there is a potential to skew the results of the monthly productivity indicator. The manager must be aware of this possibility.

Job orders, on the other hand, are typically small in scope and similar to each other. Also, comparatively there are many more job orders in the civil engineering system than there are other forms of work. As a result, the averaging effect described above almost negates the inequity.

To reinforce the statements of the previous paragraphs, a Wang Report Utility was generated on the WIMS. The purpose was to determine frequency and duration of job orders and work orders. A total of 26,294 job orders and 721 work orders completed from October 1984 to April 1985 were examined. Table IX displays the results.

TABLE IX

AVERAGE ESTIMATED AND ACTUAL HOURS BY WORK TYPE

Type Work	Number Examined	Average Estimated Hours	Average Actual Hours
Emergency Job Orders	5676	2.73	5.31
Urgent Job Orders	14260	2.42	7.12
Routine Job Orders	5670	7.03	13.71
SMART Job Orders	295	58.51	42.76
M/Const Job Orders	393	6.95	15.41
Work Orders	721	149.69	244.59

Since no better approach could be developed, the initial concept of applying the indicator to the work completed within a time period was used. As stated earlier, the averaging effect should compensate for inequities when applying the indicator to job orders. For work orders spanning more than one time period, however, the manager must be aware that unusually large work orders, can skew the results. In these cases, the large work orders must be identified and separately considered. An assessment must be made as to how the weighted production count will be apportioned among the concerned time periods.

Job and Work Order Processing. The processing of job and work orders follow similar paths in the computer program.

1. Read Data. For a given time period, only work records showing labor hours (that is, actual labor charged to the job) and falling within the time frame were considered. For work orders, an additional criteria was considered--work

order indicator. Only work orders having a "A," "X," "Y," or "W" indicator were considered. These indicators describe work orders that were accomplished by or supported with in-house (Operations Branch) personnel (33:8-27, 8:28).

2. Apply Factors. Using the Engineered Performance Standard (or planner's estimate when the EPS could not be applied, or a combination of both) the factors developed in the previous section were applied. For work orders, the factors were applied after the work estimate was obtained from the EPSPHASE file. For job orders, the work estimate was taken directly from the job order data record.

3. Allocate Result to Shop. For work orders, the EPSPHASE file retains the work estimate by shop. Therefore, allocating the weighted production count to a specific shop was easily and directly performed. For job orders, however, application was not as simple.

Each job order can document up to four different shops (counting the "Do-it-Now" personnel as the fourth shop) working on the job. But, only one work estimate is provided on the job order. A problem arises when more than one shop does work on a job order. How will the single work estimate be allocated?

Using actual labor hours and the assumption that actual labor hours are representative of the effort expended on the job, a ratio was used to allocate the weighted production count. The ratio used was actual shop hours to total actual hours. For example, consider a two shop job order where Shop

A expends two labor hours, while shop B expends six labor hours. Using the ratio process, Shop A would receive .25 (2 divided by 8) of the weighted production count, while Shop B would receive .75 (6 divided by 8).

4. Output Structure. After all the weighted production counts are calculated for the period considered, they are grouped by section, then the sections grouped to yield an overall result for the branch.

Recurring Maintenance. As was discussed under data collection, recurring maintenance data is not contained in the 2750th Civil Engineering WIMS. Therefore, the customer service contribution due to recurring maintenance could not be evaluated. Recurring maintenance control files, however, were obtained from Tinker AFB.

An examination of the control files reveals that WIMS records the necessary data to allow application of the productivity indicator. The necessary data contained is facility number, completion date, responsible shop, and standard work estimate.

In sum, the contribution of recurring maintenance to customer service can be evaluated by applying the productivity indicator.

Results of Program

This section presents the computed results. These results will later be used to answer the third investigative question.

The period considered for application of the program was October 1984 to April 1985. The program was applied in monthly increments. Appendix C contains the program's output. Table X summarizes the output and applies the Quality Factors previously determined.

TABLE X

OPERATIONS BRANCH WEIGHTED PRODUCTION COUNT BY MONTH

Month	WPC From Program	x	Quality Factor	=	Overall WPC
Oct 84	14667.3		.95		13933.9
Nov 84	26914.2		.95		25568.5
Dec 84	19909.7		.99		19710.6
Jan 85	21328.4		.99		21115.1
Feb 85	16464.7		.98		16135.4
Mar 85	28149.4		.98		27586.4
Apr 85	28822.6		.96		27669.7

Analysis of the Ouput

This section answers the final investigative question: How do the indicator's computed results generally compare to manager perceptions of productivity. To answer this question, typical information used by managers to assess productivity was gathered. Using this information, managers were asked to evaluate their customer service for the periods under study. A comparison of the evaluation was then drawn against the calculated weighted production count.

Table XI displays the information gathered for the managers' evaluation. The information was gathered from the

Operations and Industrial Engineering Branches. Weather data, however, was obtained from the Base Weather Squadron.

TABLE XI

INFORMATION USED BY MANAGERS TO ASSESS PRODUCTIVITY

	Oct84	Nov84	Dec84	Jan85	Feb85	Mar85	Apr85
% Manhours	67.8	64.1	62.3	69.2	66.0	70.1	71.4
Job Orders Completed	3195	3358	3499	4256	2324	4195	4136
Work Orders Schedule/Compl	108/ 86	80/ 58	86/ 69	91/ 80	72/ 56	76/ 67	*
% Compliance	84	83	78	73	80	73	86
% Bench Stock Availability	81	79	80	83	84	82	84
% Direct Hrs for RMP	approximately 26 percent						
Job Quality % $\geq$ Sat	94.9	95.2	99.4	98.9	98.1	98.5	95.8
Temperature Mean Hi/Lo (F)	69/ 52	48/ 32	48/ 32	27/ 17	32/ 17	52/ 34	69/ 47
Prec/Snow (in)	3.1/ 0.0	4.4/ 1.0	4.1/ 4.0	1.1/ 10.2	2.0/ 9.8	5.1/ Trace	1.4 Trace
Prime BEEF Manhours	1780	523	634	137	2916	432	1017
% Direct Prime BEEF	1.2	0.4	0.5	0.1	2.6	0.5	0.9

* Data not available for meeting

A meeting of managers was held to discuss the Operations Branch's work output. Present at the meeting were:

(1) James Dawson, Chief of Industrial Engineering

(2) Veron Gregory, Deputy Chief of Operations

(3) Charles Huber, Chief of Requirements

(4) Arlyn Johnson, Chief of Production Control

These managers were asked to evaluate the customer service output of the Operations Branch. Their objective was to rate the monthly output using a scale from 1 (unsatisfactory) to 5 (outstanding). To achieve the objective, they were asked to use the information displayed in Table XI and their experience from the period being evaluated.

Table XII compares their results against the results computed earlier.

TABLE XII

WEIGHTED PRODUCTION COUNTS AND MANAGER EVALUATIONS

Month	Production Count	Manager Evaluation
Oct 84	13933.9	4
Nov 84	25568.5	4
Dec 84	19710.6	5
Jan 85	21115.1	5
Feb 85	16135.4	3
Mar 85	27586.4	5
Apr 85	27669.7	5

After the managers made their assessements, they were shown the computed results. The managers stated the low production count in October 1984 was probably due to using a

work order to record seasonal maintenance. They elaborated by saying their seasonal maintenance was performed in September, October, and finally completed in November. As was discussed earlier, the program's approach counted only work completed during a time period. Since the seasonal maintenance work order was recorded as closed in November, that month was allocated the weighted production count.

A review of Table XII shows the computed results generally correlate with the managers' assessment. However, since comparisons were only made for seven months, and at only one base, validity of the indicator remains inconclusive.

Summary

This chapter described and analyzed the computer program generated by this study. The chapter first explained why only job and work orders would be assessed in the program, and while recurring work should have been, the 2750th Civil engineering WIMS did not contain the necessary data.

Next, the chapter presented the factors used by the productivity indicator and followed with a discussion about the program. Using guidance from civil engineering regulations and information from the Operations Branch, the original Project IMAGE factors were expanded. Using the Wang VS BASIC programming language, the factors were used to calculate the weight production counts for job and work orders. This process was first categorized by shop, and later grouped into sections. Finally, the overall branch result was determined.

The chapter later compared the computed results against manager evaluations of work for the same time periods. While no definite conclusion could be drawn, the results of this analysis do indicate a general correlation.

Throughout this chapter limitations surrounding the application of the indicator were discussed. First, the inability to quantify recurring work limits evaluation of about 25% of the branch's direct work output. Second, the computer can only systematically associate a job with a facility and not to a specific function within that facility. Mission impact could be better evaluated if the job is identified to a function instead of a facility. Third, the ability to systematically identify when a job had to be done again does not exist. This inhibits a full assessment of civil engineering job quality and effectiveness.

In conclusion, this chapter does establish that the Project IMAGE productivity indicator can be employed. Although some limitations exist, preliminary results do show the indicator generally compares with manager evaluations.

VI. Conclusions and Recommendations

Overview

This chapter presents the conclusions acquired from the development and testing of a Project IMAGE productivity indicator designed to measure the civil engineering customer service output. Also presented are the limitations that hindered application of the indicator. The chapter concludes with recommendations for further study in this area.

Conclusions

The primary objective of this thesis was to further develop a Project IMAGE productivity indicator and test its application at the 2750th Civil Engineering Operations Branch. To achieve this objective three questions were answered.

1. What further factor development is needed to use the productivity indicator?

2. What computer software is needed to employ the productivity indicator?

3. How do the indicator's computed results generally compare to manager perceptions of productivity?

The research objective and accompanying investigative questions have lead the author to draw specific conclusions.

1. The customer service output of a Civil Engineering Operations Branch can be assessed using the Project IMAGE productivity indicator. This conclusion has implications for

civil engineering managers. First, the indicator provides managers with a method that quantifies work output--puts a number to it. This number not only evaluates production, but also considers the timeliness of the work; job quality; value to the mission; and job difficulty. Second, managers can compare their performance from one period to another. Third, this capability enhances the manager's ability to set measureable goals in terms of customer service.

2. The Project IMAGE indicator can be employed using the information currently maintained by civil engineering. Once the software is loaded into the work information management system, civil engineering personnel will not be burdened to collect additional data to make the indicator work. Using existing data, however, places some limitations on the output.

Limitations

As stated in Chapter I, this study was a "first step." Its purpose was to further develop and demonstrate application of a Project IMAGE productivity concept on the 2750th Civil Engineering Operations Branch. In do so, two main limitations were encountered.

First, available data was limited. The study collected seven months of work data from the 2750th Civil Engineering Operations Branch. Although enough job order and work order information was available, the 2750th Civil Engineering Operations Branch did not maintain recurring maintenance data on their work information management system. Thus, recurring

maintenance could not be processed in this study. Since this type work constitutes about 25% of the total direct work output of the branch, a full evaluation could not be made.

Second, specific limitations within civil engineering restricted full application of the productivity indicator.

1. Civil engineering does not associate facility category codes with the work requirement. Further, systematic (i.e. using the WIMS) association of the work site to a category code can not be currently done. The current system does associate the facility number with the work; however, many facilities have multiple functions. And, associating the work only to the facility may not reflect the work's true value relative to the mission. On the other hand, category codes identify a specific function and do reflect a relationship to the mission.

2. Civil engineering can not systematically determine when one job is a repeat of another. Merely relying on work descriptions is inadequate. Work descriptions are typically generic, especially on job orders, and often result in different repairs for the same work description. From a quality assurance viewpoint, accurately assessing repeat work provides a good indicator of the quality of work performed by the Operations Branch.

3. Civil engineering provides little guidance on timeliness criteria for work order completion. Admittedly, detailed criteria for work order timeliness should be specific to an installation. Nevertheless, general

guidelines are needed. Currently, the number of backlogged work orders serves as a general indicator to when work orders will be completed. This approach, however, is imprecise and difficult to apply systematically to specific work orders.

4. Civil engineering has problems determining the actual work output for a specific time period (i.e. monthly or weekly). It can, however, quantify the actual labor hours expended in a time period. But, this is not the same as the actual work accomplished. To illustrate the difference, consider a job determined by Engineered Performance Standards to require 20 labor hours (the 20 hours are presumed to reflect the actual work required since it was determined through EPS). One work crew may expend 25 hours and another 15 hours, but both have done the same work.

If all the actual work is accomplished in one time period, the connection can easily be made to that time period. The problem arises when the work spans more than one period--the amount of actual work completed per time period is not determined. Civil engineering can quantify the labor hours expend per time period, but not necessarily the actual work. To better evaluate the civil engineering output, an assessment needs to be made in terms of actual work output.

Recommendations

Further study of the Project IMAGE productivity indicator is recommended. This thesis has provided the foundation for using the indicator. Further research should

focus on determining its validity. Validation may be accomplished by applying the concept at other civil engineering organizations and establishing a large data base of computed results. Statistical methods can then be used to correlate the computed results to manager perceptions of productivity. In this study, an evaluation of customer service output was done by civil engineering managers and compared against the computed results. This comparison showed a favorable relationship, but this evaluation was limited and is not conclusive evidence for validity. Again, this study focused on application, and the evaluations made should not be construed as validating the concept.

Although validity of the concept has not been established, the author recommends the computer software developed in this thesis be distributed to those civil engineering organizations possessing a WIMS capability. The potential to assist civil engineering managers, in this instance, is worth the minimal effort required to implement the indicator.

Finally, further research should be done on the four areas previously discussed under specific limitations.

1. Use of facility category codes to identify specific work locations.

2. Systematic identification of repeat work.

3. Guidance for work order timeliness criteria.

4. Quantifying actual work output by time period.

Closing

This study is another contribution in the Air Force search to increase work force productivity. As the introduction noted, managers at all levels are daily challenged to increase productivity. In short, managers must continue to do more--with less. The thrust behind this study was to provide civil engineering managers a better tool to assess their productivity. The search for increased productivity begins with knowing what your productivity is now.

AD-A160 925 A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPE..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. J IBANEZ 2/2

UNCLASSIFIED SEP 85 AFIT/GEM/LSM/85S-7 F/G 5/1 NL

END

FILMED

DTIC

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Appendix A: Project IMAGE Productivity Indicator

This appendix contains the productivity indicator used in this study, as presented by the Project IMAGE Team in their unpublished report Performance Management Indicators.

CUSTOMER SERVICE. The maintenance, repair and minor construction done to satisfy direct customer requests for service can be done in-service through job orders and work orders or by contract in 52X projects.

(1) Items completed on time. Customer response thresholds should be established (Emergency-48 hours; Urgent-5 days; Routine-30 days; Work orders-20 days; Projects-12 months). Clock should be started when a valid request is accepted.

(a) Just count the tasks done within the time constraint in each area. Minimum standard ___% of all tasks must be done on time.

(b) Trying to count number of customers that are "satisfied" with our customer service system. "Satisfied" is an objective measure based on response standards rather than how the customer feels. Tighter standards (e.g., 24-hours versus 48-hours for emergencies) will be more costly. This measure provides Quantity and Timeliness measurement.

(c) Should be no problem making this count.

(2) Items completed late. See (1) above.

(a) Count those tasks on a sliding scale completed late relative to the standard response threshold. Maximum standard: ____% can be done late. For example:

Routine Job Orders
30-60 days
60-120 days
120-240 days
240-or more days

(b) Trying to count partially satisfied customers. Want to show degraded service by late response to valid customer requirements. Shows impact of non-responsive supply support. Shows impact of peak workloads. Shows impact of command direct (off the wall) programs. Shows quanity and timeliness.

(c) Again no real problem to count. Already do this.

(3) Rework. Items of immediate customer service that must be done again within 7 days of completion. For contract projects include change orders due to design deficiency.

(a) Count those tasks that were repeat requirements from the customer. No more than ____% of tasks can be reworked,

(b) Want to show quality of repair work in addition to quantity. Will show supply funding impact, training impact, crash project impact, supervision impact.

(c) Big problem to count in a manual system. However, with WIMS (and the standards) can implement a count at no cost.

(4) Work not done. Direct count of valid customer request, accepted, overdue, and not done.

(a) Count the delinquent backlogs of work by type of work.

(b) Want to count dissatisfied customers. No more than ____items in this category at any time. Not a goal but a threshold of action. Reallocation resources, drastic supply actions, management problem solving.

(c) Already counted.

(5) Total production count. Want to have a common denominator to add all customer service tasks showing relative size and total quantity of production.

(a) Use the Engineered Performance Standard (EPS) estimated hours (not actual) as the relative size of jobs completed. Use the manpower equivalent hours for contracts. Add the EPS hours, for all jobs completed during the time period to show a total production.

(b) Although this number is not a visible end product, it is a good measure of work done. Can calculate for each shop. Can compare production to resources consumed. Can show increased production with improved vehicle support. Great side benefit is an improved EPS utilization. If measured with EPS, foreman and supervisor will make it better.

(c) In-house EPS is applied to all customer service work except emergency. Can implement now. However, seems to be a cumbersome arithmetic task. Can be programmed in WIMS at zero cost. Will need a Quality Control review of

EPS Application to assure EPS is correctly applied versus sandbagging.

(6) Total Productivity Factor. Use the EPS and man-hour counting with a value weighing system that encodes quality, timeliness, difficulty, and mission impact to show total customer service performance for both in-house and contract work forces.

(a) Formula:

E = EPS or manpower equivalents.
t = timeliness factor.
W = relative weight value which is a combination of time urgency of the job and the mission impact of the facility.

For each completed job calculate E x t x W.

t = Timeliness/Quality factor.

On-time 1.0

Late .9 .8 .7 .6 Sliding scale different for each response

Rework .65

W = Value Weighing Factor Grid

Urgency — Facility Type

Urgency	CCC	Airfield	Industrial	Admin	HSG Dorms	MWR
Emergency	1.0	.97	.95	.90	.90	.89
Urgent	.95	.95	.90	.85	.90	.80
Routine	.92	.90	.80	.80	.85	.80
Work Order-MC	.92	.85	.90	.85	.75	.70
Work Order-M&R	.9	.87	.85	.75	.80	.70
Contracts-Near	.9	.85	.85	.75	.80	.70
Contracts-Long	.9	.85	.85	.75	.80	.70

(just an example)

-calculate Etw for each task completed
-add all jobs completed to get total weighted production

3,541.25 utils

(b) Shows the total weighted production including all factors related to production.

-Quantity.
-Quality.
-Timeliness.

-Urgency/Difficulty.
-Relative value from a customer service perspective.
-Relative value related to the mission. Can <u>compare</u> week-to-week, month-to-month. Can <u>compare</u> to resources consumed (people, vehicles, supplies, computers). Shows impact of supply response, vehicle support, training. Only good for comparison.

(c) Develop software on WIMS to calculate and analyze the output.

Appendix B: Computer Program

This appendix contains the computer program used in this study to assess the Civil Engineering Operations Branch's "Customer Service" output. Before presenting the program, key variables used will be defined.

Definition of Variables

1. DIN_VEH_NR$ - DIN vehicle number on job order.
2. ENDDATE$ - last date of time period under review.
3. EPS_HOURS$ - EPS hours on job order.
4. EPSHOURS$ - total estimate of work (EPS and Planner) per work order phase.
5. EPSSHOP$ - FAC for shop in work orders.
6. FACILITY_CATEGORY$ - category of facility (A-F).
7. FACILITY_NUMBER$ - installation code and facility number.
8. FACNR$ - facility number.
9. HOURS_DIN$ - actual DIN hours on job order.
10. HOURS_SHOP1$ - actual hours for 1st shop on job order.
11. HOURS_SHOP2$ - actual hours for 2nd shop on job order.
12. HOURS_SHOP2$ - actual hours for 3rd shop on job order.
13. INSTLCDE$ - installation code.
14. JOB_INDATE$ - date work is received.
15. JOB_INDATE1$ - date work order opened in WCM.
16. JOBORDER$ - data file designator used to increment job order data files.
17. PCOUNT - 1D array used to store weighted production counts.
18. PHASEKEY$ - work order number, work requirement, and phase number.
19. SHOP0$ - FAC for DIN vehicle.
20. SHOP1$ - FAC of 1st shop on job order.
21. SHOP2$ - FAC of 2nd shop on job order.
22. SHOP3$ - FAC of 3rd shop on job order.
23. STARTDATE$ - beginning date of time period under review.
24. TOTAL_ACTUAL_HRS$ - job order total actual hours.
25. TOTHRS$$ - work order total actual hours.
26. TYPESVC$ - type job order: E,U,R,S,M.
27. WCMPRIOR$ - work order priority.
28. WKCLASS$ - work order total actual hours.
29. WOIND$ - work order indicator.
30. WONR$ - installation code, control center code, and work order number.
31. WORK_CATEGORY$ - indicator work category.
32. WORKORDER$ - data file designator use to increment work order data files.

```
*****************************************************************
*                 WEIGHTED PRODUCTION COUNT PROGRAM             *
*                                BY                             *
*                  FIRST LIEUTENANT JUAN IBANEZ JR              *
*                AFIT SCHOOL OF SYSTEMS AND LOGISTICS           *
*                             JUNE 1985                         *
*                                                               *
*   THIS PROGRAM APPLIES A PROJECT IMAGE GENERATED PRODUCTIVITY *
*   INDICATOR DESIGNED TO QUANTIFY THE CIVIL ENGINEERING OPERA- *
*   TIONS BRANCH'S "CUSTOMER SERVICE" OUTPUT  IN ESSENCE, THE   *
*   PROGRAM PRODUCES A WEIGHTED PRODUCTION COUNT FOR THE BRANCH, *
*   AND EACH SHOP AND SECTION  IN CONCEPT, THE PROGRAM TAKES    *
*   ENGINEERED PERFORMANCE STANDARD (EPS) HOURS APPLIED TO JOB  *
*   AND WORK ORDERS, THEN PROCESSES THESE HOURS AGAINST TIMELI- *
*   NESS, WORK PRIORITY, AND FACILITY-TYPE FACTORS  WHERE EPS   *
*   HOURS CANNOT BE APPLIED TO THE WORK, THE PLANNER'S ESTIMATE *
*   IS COMBINED WITH THE EPS HOURS TO YIELD AN OVERALL WORK EST- *
*   IMATE  NOTE  THIS PROGRAM WAS TAILORED TO THE 2750TH CIVIL  *
*   ENGINEERING OPERATIONS BRANCH  AS SUCH, ITS USE ELSEWHERE   *
*   WILL REQUIRE SOME ADJUSTMENTS.                              *
*                                                               *
*   THE PROGRAM CODE IS WANG VS BASIC (VERSION 3.4.2) COMPUTER  *
*   LANGUAGE AND WAS INPUTTED VIA WANG VS INTEGRATED EDITOR     *
*   (VERSION 6 11 00)  WHEN COMPILED, THIS PROGRAM MUST BE      *
*   LINKED TO "USERSUBS."                                       *
*****************************************************************
*****************************************************************
*                      DIMENSION VARIABLES                      *
*****************************************************************
DIM JOB_INDATE$ 06, FACILITY NUMBER$ 09, EPS_HOURS$ 03,          !
    DIN VEH NR$ 02, HOURS DIN$ 03, SHOP1$ 03, TYPESVC$ 01,       !
    HOURS_SHOP1$ 03, SHOP2$ 03, HOURS_SHOP2$ 03, SHOP3$ 03,      !
    HOURS_SHOP3$ 03, COMPLETE DATE$ 06, TOTAL_ACTUAL_HRS$ 03,    !
    WONR$ 10, WCMPRIOR$ 01, WKCLASS$ 01, TOTHRS$ 09, FACNR$ 05,  !
    PHASEKEY$ 17, EPSSHOP$ 03, EPSHOURS$ 04, INSTLCDE$ 04,       !
    FACILITY_CATEGORY$ 01, JOBORDER$ 06, WORKORDER$ 07,          !
    SHOP$(22) 03, PCOUNT(22), SHOPO$ 03, STARTDATE$ 06,          !
    ENDDATE$ 06, ZONEDHOURS$ 03, NEWHOURS$ 05, WOHRS$ 18,        !
    WORK_CATEGORY$ 01,NEWWOHRS$ 11,NEWDATE$ 06, WINDOW$ 06,      !
    JOB_INDATE1$ 06, WOIND$ 01
*****************************************************************
*                          SELECT FILES                         *
*****************************************************************
SELECT #1, "MJOBH", INDEXED, RECSIZE=0899, KEYPOS=1,             !
           KEYLEN=5,  ALT KEY 6, KEYPOS=592, KEYLEN=6, DUP,      !
           EOD GOTO  INCREMENTWINDOW
SELECT #2, "MWOJOBH", INDEXED, RECSIZE=1920, KEYPOS=1,           !
           KEYLEN=10, EOD GOTO DONEWORKORDER
```

```
SELECT #3, "EPSPHASE", INDEXED, RECSIZE=0640, KEYPOS=1,            !
           KEYLEN=17
SELECT #4, "RPD", INDEXED, RECSIZE=0040, KEYPOS=1, KEYLEN=9
********************************************************************
*                             OPEN FILES                           *
********************************************************************
OPEN NODISPLAY #3, SHARED, FILE="EPSPHASE", LIBRARY="LJIDATA",     !
                       VOLUME="SYS"
OPEN NODISPLAY #4, SHARED, FILE="RPD", LIBRARY="LJIDATA",          !
                       VOLUME="SYS"
********************************************************************
*                          MESSAGE TO CRT                          *
********************************************************************
ACCEPT                                                             !
         AT (05,10),                                               !
"THIS PROGRAM CALCULATES WEIGHTED PRODUCTION COUNTS FOR OPERA-",   !
         AT (06,10),                                               !
"TIONS SHOPS, SECTIONS, AND THE BRANCH.  DATA IS COLLECTED",       !
         AT (07,10),                                               !
"ONLY FROM WORK AND JOB ORDERS.  TO BEGIN, PLEASE ENTER THE",      !
         AT (08,10),                                               !
"INCLUSIVE DATES YOU WISH TO INVESTIGATE USING THE FOLLOW-",       !
         AT (09,10),                                               !
"ING FORM (YYMMDD)",                                               !
         AT (13,25), STARTDATE$, CH(6),                            !
         AT (13,33),                                               !
"TO",                                                              !
         AT (13,38), ENDDATE$, CH(6)
DISPLAY AT (11,20),                                                !
"NOW CALCULATING WEIGHTED PRODUCTION COUNT."
*******************************************************************
FOR I = 1 TO 22 STEP 1
READ SHOP$(I)
NEXT I
DATA "441","442","443","447","451","452","453","454","455","457"
DATA "461","462","463","465","469","471","472","480","491","493"
DATA "494", "433"
********************************************************************
*        CALCULATE PRODUCTION COUNT FOR JOB ORDERS                 *
********************************************************************
FOR N=1 TO 3 STEP 1
IF N=1 THEN JOBORDER$="MJOBH"
IF N=2 THEN JOBORDER$="MJOBH1"
IF N=3 THEN JOBORDER$="MJOB"
OPEN NODISPLAY #1, SHARED, FILE=JOBORDER$, LIBRARY="LJIDATA",      !
                       VOLUME="SYS",BLOCKS=3
NEWDATE$=STARTDATE$
STARTSEARCH
```

```
009700 READ #1, KEY(6)=NEWDATE$   GOTO 9900
009800 READJOBRECORD: READ #1
009900 GET #1,  USING FMT1, JOB_INDATE$, FACILITY NUMBER$, EPS_HOURS$,   !
010000          DIN_VEH_NR$, HOURS_DIN$, SHOP1$, HOURS SHOP1$, SHOP2$,   !
010100          HOURS_SHOP2$, SHOP3$, HOURS_SHOP3$, COMPLETE_DATE$,      !
010200          TOTAL_ACTUAL_HRS$, TYPESVC$
010300 IF COMPLETE_DATE$<>NEWDATE$ THEN GOTO INCREMENTWINDOW
010400 FMT1:FMT XX(5),CH(6), XX(5), CH(9), XX(274), CH(3),               !
010500          XX(155), CH(2), XX(10), CH(3), XX(17), CH(3), XX(11),   !
010600          CH(3), XX(17), CH(3), XX(11), CH(3), XX(17),            !
010700          CH(3), XX(11), CH(3), XX(17), CH(6), CH(3)
010800 ZONEDHOURS$=TOTAL ACTUAL HRS$:GOSUB CONVERT_HOURS
010900 TOTAL ACTUAL HRS=NEWHOURS
011000 IF TOTAL ACTUAL_HRS <= 0 0 THEN GOTO READJOBRECORD
011100 ZONEDHOURS$=EPS HOURS$:GOSUB CONVERT_HOURS:EPS_HOURS=NEWHOURS
011200 ZONEDHOURS$=HOURS_DIN$:GOSUB CONVERT HOURS:HOURS DIN=NEWHOURS
011300 ZONEDHOURS$=HOURS_SHOP1$:GOSUB CONVERT_HOURS:HOURS_SHOP1=NEWHOURS
011400 ZONEDHOURS$=HOURS SHOP2$:GOSUB CONVERT HOURS:HOURS_SHOP2=NEWHOURS
011500 ZONEDHOURS$=HOURS SHOP3$:GOSUB CONVERT_HOURS:HOURS_SHOP3=NEWHOURS
011600 GOSUB DETERMINE_FACILITY_CATEGORY
011700 WORK CATEGORY$ = "  "
011800 IF TYPESVC$    =  "E"      THEN WORK_CATEGORY$  =  "A"
011900 IF TYPESVC$    =  "U"      THEN WORK_CATEGORY$  =  "B"
012000 IF TYPESVC$    =  "R"      THEN WORK_CATEGORY$  =  "C"
012100 IF TYPESVC$    =  "S"      THEN WORK_CATEGORY$  =  "C"
012200 IF TYPESVC$    =  "M"      THEN WORK_CATEGORY$  =  "C"
012300 IF (WORK_CATEGORY$=" ") THEN WORK CATEGORY$="C"
012400 GOSUB W_FACTOR_MATRIX:GOSUB DETERMINE_JOB_DURATION
012500 GOSUB DETERMINE_TIME_FACTOR
012600 IF (DIN_VEH_NR$="70") OR (DIN VEH NR$="14") THEN SHOPO$="471"
012700 IF (DIN VEH NR$="52") OR (DIN VEH NR$="97") THEN SHOPO$="453"
012800 PRODUCTION COUNT = EPS_HOURS * WFACTOR * TIMEFACTOR
012900 ALLOCATED_PROD_COUNTO=(HOURS_DIN/TOTAL_ACTUAL_HRS)               !
013000     *PRODUCTION_COUNT
013100 ALLOCATED_PROD_COUNT1=(HOURS_SHOP1/TOTAL_ACTUAL_HRS)             !
013200     *PRODUCTION_COUNT
013300 ALLOCATED_PROD_COUNT2=(HOURS_SHOP2/TOTAL_ACTUAL_HRS)             !
013400     *PRODUCTION_COUNT
013500 ALLOCATED_PROD_COUNT3=(HOURS_SHOP3/TOTAL_ACTUAL_HRS)             !
013600     *PRODUCTION_COUNT
013700 FOR I = 1 TO 22 STEP 1
013800      IF (SHOPO$=SHOP$(I))  THEN                                  !
013900         PCOUNT(I) = PCOUNT(I) + ALLOCATED_PROD_COUNTO
014000 NEXT I
014100
014200 FOR I = 1 TO 22 STEP 1
014300      IF (SHOP1$=SHOP$(I))  THEN                                  !
014400         PCOUNT(I) = PCOUNT(I) + ALLOCATED_PROD_COUNT1
```

```
014500 NEXT I
014600
014700 FOR I = 1 TO 22 STEP 1
014800      IF (SHOP2$=SHOP$(I))  THEN                                          !
014900          PCOUNT(I) = PCOUNT(I) + ALLOCATED_PROD_COUNT2
015000 NEXT I
015100
015200 FOR I = 1 TO 22 STEP 1
015300      IF (SHOP3$=SHOP$(I))  THEN                                          !
015400          PCOUNT(I) = PCOUNT(I) + ALLOCATED_PROD_COUNT3
015500 NEXT I
015600 GOTO READJOBRECORD
015700 INCREMENTWINDOW
015800 GOSUB SEARCHWINDOW
015900 IF WINDOW$>ENDDATE$ THEN GOTO DONEJOBORDER
016000 NEWDATE$=WINDOW$ :GOTO STARTSEARCH
016100 DONEJOBORDER CLOSE #1:NEXT N
016200 ************************************************************ *
016300 *            CALCULATE PRODUCTION COUNT FOR WORK ORDERS              *
016400 **************************************************************
016500 FOR P=1 TO 2 STEP 1
016600 IF P=1 THEN WORKORDER$="MWOJOBH"
016700 IF P=2 THEN WORKORDER$="MWOJOB"
016800 OPEN NODISPLAY #2, SHARED, FILE=WORKORDER$, LIBRARY="LJIDATA",    !
016900                          VOLUME="SYS",BLOCKS=5
017000 READ_A_WORK_ORDER_RECORD
017100 READ #2, USING FMT2,  WONR$, WCMPRIOR$,WOIND$, WKCLASS$,            !
017200             INSTLCDE$, FACNR$,JOB_INDATE1$,COMPLETE_DATE$,TOTHRS$,   !
017210             JOB_INDATE$
017300 FMT2:  FMT CH(10), XX(1), CH(1),CH(1), CH(1), XX(6),                 !
017400 CH(4),XX(5), CH(5), XX(90), CH(6), XX(30), CH(6), XX(96), CH(9),    !
017410 XX(331), CH(6)
017500 IF (JOB_INDATE$="      ") THEN JOB_INDATE$=JOB_INDATE1$
017600 IF (COMPLETE_DATE$ < STARTDATE$) OR                                  !
017700 (COMPLETE_DATE$ > ENDDATE$)  THEN GOTO READ_A_WORK_ORDER_RECORD
017710 IF (WOIND$ <> "A") AND (WOIND$ <> "X") AND (WOIND$ <> "W") AND      !
017720    (WOIND$ <> "Y")  THEN  GOTO READ_A_WORK_ORDER_RECORD
017800 CALL "HEXUNPK" ADDR(TOTHRS$, WOHRS$, 9%)
017900 NEWWOHRS$=" " & STR(WOHRS$,2,1) & STR(WOHRS$,4,1) &                  !
018000              STR(WOHRS$,6,1) & STR(WOHRS$,8,1) & STR(WOHRS$,10,1)    !
018100              & STR(WOHRS$,12,1) & STR(WOHRS$,14,1) &                 !
018200              STR(WOHRS$,16,1) & "." & STR(WOHRS$,18,1)
018300 IF STR(WOHRS$,17,1) = "D" THEN STR(NEWWOHRS$,1,1) ="-"
018400 CONVERT NEWWOHRS$ TO NEWWOHRS
018500 IF NEWWOHRS <= 0 0 THEN GOTO READ_A_WORK_ORDER_RECORD
018600 FACILITY_NUMBER$=STR(INSTLCDE$,1,4) & STR(FACNR$,1,5)
018700 GOSUB DETERMINE_FACILITY_CATEGORY
018800 WORK_CATEGORY$=" "
```

```
IF (WCMPRIOR$="1") OR (WCMPRIOR$="2") THEN WORK_CATEGORY$ ="D"
IF (WORK CATEGORY$="D") THEN GOTO BYPASS
IF (WKCLASS$="C") THEN WORK_CATEGORY$="F"
IF (WORK_CATEGORY$="F") THEN GOTO BYPASS
WORK_CATEGORY$="E"
BYPASS:   PHASEKEY$=STR(WONR$,1,10) & "        "
GOSUB W_FACTOR_MATRIX: GOSUB DETERMINE_JOB_DURATION
GOSUB DETERMINE_TIME_FACTOR: GOSUB DETERMINE_WO_ESTIMATED_HOURS
GO TO READ_A_WORK_ORDER_RECORD
DONEWORKORDER: CLOSE #2:NEXT P
*************************************************************** *
*              SUM AND GROUP PRODUCTION COUNTS                  *
*****************************************************************
PAVEMENTS=PCOUNT(1)+PCOUNT(2)+PCOUNT(3)+PCOUNT(4)
STRUCTURES=PCOUNT(5) + PCOUNT(6)+PCOUNT(7)+PCOUNT(8)+PCOUNT(9)+   !
               PCOUNT(10)
MECHANICAL=PCOUNT(11)+PCOUNT(12)+PCOUNT(13)+PCOUNT(14)
SYSTEMS=PCOUNT(15)
ELECTRICAL=PCOUNT(16)+PCOUNT(17)+PCOUNT(18)
SANITATION=PCOUNT(19)+PCOUNT(20)+PCOUNT(21)
BRANCH=PAVEMENTS+STRUCTURES+MECHANICAL+ELECTRICAL+SANITATION+     !
         SYSTEMS+PCOUNT(22)
CLOSE #3: CLOSE #4
ACCEPT                                                            !
AT (01,20),   "WEIGHTED PRODUCTION COUNTS FOR THE PERIOD",        !
AT (03,28), FAC(HEX(8C)), STARTDATE$,  CH(6),                     !
AT (03,35), "TO",                                                 !
AT (03,38), FAC(HEX(8C)), ENDDATE$,    CH(6),                     !
AT (06,10), "PRODUCTION",                                         !
AT (06,30), "PRODUCTION",                                         !
AT (06,50), "PRODUCTION",                                         !
AT (06,70), "PRODUCTION",                                         !
AT (07,03), "SHOP     COUNT",                                     !
AT (07,23), "SHOP     COUNT",                                     !
AT (07,43), "SHOP     COUNT",                                     !
AT (07,63), "SHOP     COUNT",                                     !
AT ( 9,03), "441",                                                !
AT ( 9,10), FAC(HEX(8C)), PCOUNT(1), PIC(#######.#),              !
AT ( 9,23), "442",                                                !
AT ( 9,30), FAC(HEX(8C)), PCOUNT(2), PIC(#######.#),              !
AT ( 9,43), "443",                                                !
AT ( 9,50), FAC(HEX(8C)), PCOUNT(3), PIC(#######.#),              !
AT ( 9,63), "447",                                                !
AT ( 9,70), FAC(HEX(8C)), PCOUNT(4), PIC(#######.#),              !
AT (10,03), "451",                                                !
AT (10,10), FAC(HEX(8C)), PCOUNT(5), PIC(#######.#),              !
AT (10,23), "452",                                                !
AT (10,30), FAC(HEX(8C)), PCOUNT(6), PIC(#######.#),              !
```

```
AT (10,43), "453",
AT (10,50), FAC(HEX(8C)), PCOUNT(7), PIC(#######.#),
AT (10,63), "454",
AT (10,70), FAC(HEX(8C)), PCOUNT(8), PIC(#######.#),
AT (11,03), "455",
AT (11,10), FAC(HEX(8C)), PCOUNT(9), PIC(#######.#),
AT (11,23), "457",
AT (11,30), FAC(HEX(8C)), PCOUNT(10),PIC(#######.#),
AT (11,43), "461",
AT (11,50), FAC(HEX(8C)), PCOUNT(11),PIC(#######.#),
AT (11,63), "462",
AT (11,70), FAC(HEX(8C)), PCOUNT(12),PIC(#######.#),
AT (12,03), "463",
AT (12,10), FAC(HEX(8C)), PCOUNT(13),PIC(#######.#),
AT (12,23), "465",
AT (12,30), FAC(HEX(8C)), PCOUNT(14),PIC(#######.#),
AT (12,43), "469",
AT (12,50), FAC(HEX(8C)), PCOUNT(15),PIC(#######.#),
AT (12,63), "471",
AT (12,70), FAC(HEX(8C)), PCOUNT(16),PIC(#######.#),
AT (13,03), "472",
AT (13,10), FAC(HEX(8C)), PCOUNT(17),PIC(#######.#),
AT (13,23), "480",
AT (13,30), FAC(HEX(8C)), PCOUNT(18),PIC(#######.#),
AT (13,43), "491",
AT (13,50), FAC(HEX(8C)), PCOUNT(19),PIC(#######.#),
AT (13,63), "493",
AT (13,70), FAC(HEX(8C)), PCOUNT(20),PIC(#######.#),
AT (14,03), "494",
AT (14,10), FAC(HEX(8C)), PCOUNT(21),PIC(#######.#),
AT (14,23), "433",
AT (14,30), FAC(HEX(8C)), PCOUNT(22),PIC(#######.#),
AT (16,13), "PRODUCTION",
AT (16,37), "PRODUCTION",
AT (16,61), "PRODUCTION",
AT (17,03), "SECTION     COUNT",
AT (17,28), "SECTION    COUNT",
AT (17,52), "SECTION    COUNT",
AT (19,03), "ELECT",
AT (19,13), FAC(HEX(8C)), ELECTRICAL, PIC(#########.#),
AT (19,28), "SYSTEM",
AT (19,37), FAC(HEX(8C)), SYSTEMS,    PIC(#########.#),
AT (19,52), "STRUCT",
AT (19,60), FAC(HEX(8C)), STRUCTURES, PIC(#########.#),
AT (20,03), "P+G",
AT (20,13), FAC(HEX(8C)), PAVEMENTS,  PIC(#########.#),
AT (20,28), "MECH",
AT (20,37), FAC(HEX(8C)), MECHANICAL, PIC(#########.#),
```

```
AT (20,52), "SANIT",                                                    !
AT (20,60), FAC(HEX(8C)), SANITATION, PIC(######### #),                 !
AT (23,03), "TOTAL WEIGHTED PRODUCTION FOR BRANCH:",                    !
AT (23,48), FAC(HEX(8C)), BRANCH, PIC(######### #)
END
*****************************************************************************
*        SUBROUTINE TO COVERT ZONED NUMBERS TO REAL                          *
*****************************************************************************
CONVERT_HOURS
CALL "HEXUNPK" ADDR(ZONEDHOURS$, HRS$, 3%)
NEWHOURS$ = " " & STR(HRS$,2,1) & STR(HRS$,4,1) &                       !
            "." & STR(HRS$,6,1)
IF STR(HRS$,5,1) = "D" THEN STR(NEWHOURS$,1,1) = "-"
CONVERT NEWHOURS$ TO NEWHOURS
RETURN
*****************************************************************************
* SUBROUTINE TO CALCULATE NUMBER OF DAYS BETWEEN START/END DATES *
*****************************************************************************
DETERMINE_JOB_DURATION
JOB_DURATION%=0
CALL "DATE" ADDR("G-", JOB_INDATE$, COMPLETE_DATE$,                     !
                 JOB_DURATION%, IRET%)
RETURN
*****************************************************************************
*       SUBROUTINE TO DETERMINE SEARCH WINDOW FOR JOBORDERS                  *
*****************************************************************************
SEARCHWINDOW CALL "DATE" ADDR("G+", NEWDATE$, 1%, WINDOW$, IRET%)
*****************************************************************************
*    SUBROUTINE TO DETERMINE ESTIMATED HOURS FOR WORK ORDERS                 *
*****************************************************************************
DETERMINE_WO_ESTIMATED_HOURS
PHASEDATA  READ #3, KEY>PHASEKEY$, EOD GOTO DONEPHASEDATA
GET #3, USING FMT4, PHASEKEY$, EPSSHOP$, EPSHOURS$
FMT4  FMT CH(17), XX(20), CH(3), XX(517), CH(4)
IF STR(PHASEKEY$,1,10) <> WONR$ THEN GOTO DONEPHASEDATA
IF EPSHOURS$="0000" THEN GOTO PHASEDATA
CONVERT EPSHOURS$ TO EPSHOURS
PRODUCTION_COUNT=EPSHOURS * TIMEFACTOR * WFACTOR
FOR I = 1 TO 22 STEP 1
    IF (EPSSHOP$ = SHOP$(I)) THEN                                       !
    PCOUNT(I) = PCOUNT(I) + PRODUCTION_COUNT
NEXT I
GOTO PHASEDATA
DONEPHASEDATA RETURN
*****************************************************************************
*           SUBROUTINE TO DETERMINE FACILITY CATEGORY                        *
*****************************************************************************
DETERMINE_FACILITY_CATEGORY
```

```
FACILITY_CATEGORY$=" "
READ #4, KEY=FACILITY_NUMBER$, EOD GOTO NOSUCHNUMBER
GET #4, USING FMT5 , FACILITY_CATEGORY$
FMT5: FMT XX(20), CH(1)
NOSUCHNUMBER
IF (FACILITY_CATEGORY$=" ")  THEN FACILITY_CATEGORY$= "D"
RETURN
****************************************************************
*        SUBROUTINE TO DETERMINE WEIGHTED FACTOR              *
****************************************************************
W FACTOR MATRIX
WFACTOR=0.0
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="A")          !
    THEN WFACTOR=1.0
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="B")          !
    THEN WFACTOR=.95
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="C")          !
    THEN WFACTOR=.92
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="D")          !
    THEN WFACTOR=.94
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="E")          !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="A") AND (WORK_CATEGORY$="F")          !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="A")          !
    THEN WFACTOR=.97
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="B")          !
    THEN WFACTOR=.95
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="C")          !
    THEN WFACTOR=.87
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="D")          !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="E")          !
    THEN WFACTOR=.86
IF (FACILITY_CATEGORY$="B") AND (WORK_CATEGORY$="F")          !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="A")          !
    THEN WFACTOR=.95
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="B")          !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="C")          !
    THEN WFACTOR=.86
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="D")          !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="E")          !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="C") AND (WORK_CATEGORY$="F")          !
    THEN WFACTOR=.85
```

```
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="A")              !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="B")              !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="C")              !
    THEN WFACTOR=.80
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="D")              !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="E")              !
    THEN WFACTOR=.75
IF (FACILITY_CATEGORY$="D") AND (WORK_CATEGORY$="F")              !
    THEN WFACTOR=.75
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="A")              !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="B")              !
    THEN WFACTOR=.90
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="C")              !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="D")              !
    THEN WFACTOR=.85
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="E")              !
    THEN WFACTOR=.80
IF (FACILITY_CATEGORY$="E") AND (WORK_CATEGORY$="F")              !
    THEN WFACTOR=.80
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="A")              !
    THEN WFACTOR=.88
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="B")              !
    THEN WFACTOR=.80
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="C")              !
    THEN WFACTOR=.75
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="D")              !
    THEN WFACTOR=.78
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="E")              !
    THEN WFACTOR=.70
IF (FACILITY_CATEGORY$="F") AND (WORK_CATEGORY$="F")              !
    THEN WFACTOR=.70
RETURN
****************************************************************
*          SUBROUTINE TO DETERMINE TIMELINESS OF WORK          *
****************************************************************
DETERMINE_TIME_FACTOR
TIMEFACTOR =0.0
IF (WORK_CATEGORY$ = "A")   AND   (JOB_DURATION% <= 2)          !
    THEN TIMEFACTOR  =  1.0
IF (WORK_CATEGORY$ = "A")   AND   (JOB_DURATION%  = 3)          !
    THEN TIMEFACTOR  =  .90
IF (WORK_CATEGORY$ = "A")   AND   (JOB_DURATION%  = 4)          !
    THEN TIMEFACTOR  =  .80
```

```
IF (WORK_CATEGORY$ = "A")   AND   (JOB_DURATION%  = 5)           !
   THEN TIMEFACTOR  =  .70
IF (WORK_CATEGORY$ = "A")   AND   (JOB_DURATION% >= 6)           !
   THEN TIMEFACTOR  =  .60
IF (WORK_CATEGORY$="A") THEN RETURN
JOB_DURATION  =  JOB_DURATION%
IF WORK_CATEGORY$  =  "B"                                        !
   THEN PERCENT = (JOB_DURATION - 7.0)/7.0
IF WORK_CATEGORY$  =  "C"                                        !
   THEN PERCENT = (JOB_DURATION - 30.0)/30.0
IF  PERCENT < .00001                     THEN TIMEFACTOR = 1.0
IF (PERCENT >= .00001) AND (PERCENT < .25) THEN TIMEFACTOR = .95
IF (PERCENT >=.25    ) AND (PERCENT < .50) THEN TIMEFACTOR = .90
IF (PERCENT >= .50   ) AND (PERCENT < .75) THEN TIMEFACTOR = .80
IF (PERCENT >= .75   ) AND (PERCENT < 1.0) THEN TIMEFACTOR = .70
IF PERCENT  >= 1.0                          THEN TIMEFACTOR = .60
IF (WORK_CATEGORY$="B") OR (WORK_CATEGORY$="C") THEN RETURN
TIMEFACTOR=0.0
IF (WORK_CATEGORY$ ="D")  AND  (JOB_DURATION% < 120)            !
                              THEN  TIMEFACTOR = 1.0
IF (WORK_CATEGORY$ = "D") AND  (JOB_DURATION% >=120) AND        !
   (JOB_DURATION% < 150 ) THEN TIMEFACTOR  = .95
IF (WORK_CATEGORY$ = "D") AND  (JOB_DURATION% >=150) AND        !
   (JOB_DURATION% < 180 ) THEN TIMEFACTOR  = .90
IF (WORK_CATEGORY$ = "D") AND  (JOB_DURATION% >=180) AND        !
   (JOB_DURATION%  < 210) THEN TIMEFACTOR  = .80
IF (WORK_CATEGORY$ = "D") AND  (JOB_DURATION% >=210) AND        !
   (JOB_DURATION%  < 240) THEN TIMEFACTOR  = .70
IF (WORK_CATEGORY$ = "D") AND  (JOB_DURATION% >= 240)           !
                              THEN TIMEFACTOR   = .60
IF (WORK_CATEGORY$="D") THEN RETURN
IF (JOB_DURATION% < 180)  THEN TIMEFACTOR = 1.0
IF (JOB_DURATION% >= 180) AND (JOB_DURATION% <240)              !
                              THEN TIMEFACTOR  =.85
IF (JOB_DURATION% >= 240) AND (JOB_DURATION% <330)              !
                              THEN TIMEFACTOR  =.75
IF (JOB_DURATION% >= 330) THEN TIMEFACTOR  =.60
RETURN
****************************************************************
*                         END OF PROGRAM                       *
****************************************************************
```

Appendix C: Computer Output

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

841001 TO 841031

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	214.2	442	168.9	443	114.6	447	0.0
451	1636.6	452	968.0	453	1120.0	454	952.3
455	164.8	457	1928.2	461	793.2	462	171.1
463	984.8	465	2379.7	469	118.9	471	1565.0
472	437.2	480	93.0	491	311.9	493	188.3
494	0.0	433	355.8				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	2095.3	SYSTEM	118.9	STRUCT	6770.2
P+G	497.7	MECH	4328.8	SANIT	500.3

TOTAL WEIGHTED PRODUCTION FOR BRANCH: 14667.3

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

841101 TO 841130

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	3884.4	442	3682.0	443	656.0	447	30.0
451	2369.8	452	993.4	453	1003.1	454	1674.0
455	401.5	457	2197.2	461	1971.9	462	227.1
463	1302.9	465	2103.0	469	106.8	471	2399.1
472	799.2	480	60.1	491	555.3	493	217.3
494	0.0	433	278.9				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	3258.6	SYSTEM	106.8	STRUCT	8639.3
P+G	8252.6	MECH	5605.1	SANIT	772.7

TOTAL WEIGHTED PRODUCTION FOR BRANCH: 26914.2

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

841201 TO 841231

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	601.3	442	323 9	443	125.7	447	0.0
451	1555.6	452	781 7	453	1996.3	454	1168.9
455	177.6	457	2002 8	461	1241.1	462	162.6
463	1286 7	465	4575.3	469	107.9	471	1497.1
472	857 6	480	37.1	491	454.0	493	448.2
494	0 0	433	507.3				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	2391 9	SYSTEM	107.9	STRUCT	7683.1
P+G	1051.0	MECH	7265 9	SANIT	902.3

TOTAL WEIGHTED PRODUCTION FOR BRANCH 19909.7

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

850101 TO 850131

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	510 6	442	370 8	443	146.3	447	240.4
451	2940 7	452	1358.4	453	1177 3	454	1683.7
455	538 5	457	2122.9	461	1252.3	462	55.3
463	1804 6	465	2237.2	469	160 0	471	2435.9
472	796 1	480	168 0	491	390.1	493	499.0
494	0 0	433	439 2				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	3400 1	SYSTEM	160.0	STRUCT	9821 8
P+G	1268 2	MECH	5349 6	SANIT	889 2

TOTAL WEIGHTED PRODUCTION FOR BRANCH 21328.4

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

850201 TO 850228

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	603.8	442	599.8	443	143.3	447	0.0
451	1533.1	452	630.0	453	979.0	454	1106.0
455	362.2	457	1702.5	461	1513.0	462	120.5
463	1106.1	465	2166.6	469	139.8	471	2097.1
472	713.6	480	82.5	491	194.1	493	293.3
494	0.0	433	377.3				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	2893.3	SYSTEM	139.8	STRUCT	6313.0
P+G	1347.0	MECH	4906.5	SANIT	487.5

TOTAL WEIGHTED PRODUCTION FOR BRANCH: 16464.7

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

850301 TO 850331

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	2328.8	442	3560.3	443	146.4	447	0.0
451	4191.1	452	2245.5	453	1491.5	454	2177.0
455	810.6	457	1884.7	461	1264.1	462	174.1
463	1394.3	465	372.6	469	154.0	471	3311.2
472	1292.3	480	162.9	491	298.6	493	341.2
494	0.0	433	547.3				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	4766.6	SYSTEM	154.0	STRUCT	12800.6
P+G	6035.5	MECH	3205.3	SANIT	639.8

TOTAL WEIGHTED PRODUCTION FOR BRANCH 28149.4

WEIGHTED PRODUCTION COUNTS FOR THE PERIOD

850401 TO 850430

SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT	SHOP	PRODUCTION COUNT
441	1216 2	442	899.2	443	619.3	447	111.2
451	3968.1	452	1823.8	453	3201.6	454	3096.2
455	1522 2	457	2613.3	461	1660.3	462	188.7
463	2337.6	465	80.6	469	201.2	471	3106.4
472	625.2	480	163.7	491	406.1	493	467.3
494	0.0	433	513.3				

SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT	SECTION	PRODUCTION COUNT
ELECT	3895.4	SYSTEM	201 2	STRUCT	16225.5
P+G	2846.1	MECH	4267.3	SANIT	873.5

TOTAL WEIGHTED PRODUCTION FOR BRANCH: 28822.6

Bibliography

1. Anthony, Robert N. and David W. Young. Management Control in Nonprofit Organizations (3rd ed.). Homewood IL: Richard D. Irwin, 1984.

2. Arnold, Palmer G. and David P. Fink. Hierarchical Model of Objectives and Performance Indicator for the Base Civil Engineer. MS Thesis, LSSR 19-74A. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, January 1974 (AD-A777 248).

3. Baker, Jack T. and James R. Kennedy. "Productivity: What is it? How is it Measured?" The Military Engineer, 73: 182-184 (May-June 1981).

4. Baldetti, Peter J. et al. "Productivity Development for the Base Civil Engineer." Unpublished paper for LM 5.55, AFIT/LS, Wright-Patterson AFB OH, September 1983.

5. Baumgratel, Gary P. and Thomas D. Johnson. Productivity Measurement in a Base Level USAF Civil Engineering Organization. MS Thesis, LSSR 17-79A. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, June 1979 (AD-A073 017).

6. Burcher, William et al. "Development of a Method to Measure the Productivity of USAF Base Civil Engineering Units." Unpublished paper for LM 5.55A, AFIT/LS, Wright-Patterson AFB OH, September 1982.

7. Burgess, Danny N. Base Civil Engineering Organizational Effectiveness: An Analysis of Performance Evaluation Criteria. Unpublished technical report, number 295, Air University/Air War College, Maxwell AFB AL, April 1978.

8. Cameron, Kim. "Critical Questions in Assessing Organizational Effectiveness," Organizationl Dynamics, 24: 66-80 (Autumn 1980).

9. Chace, Harvey D. Civil Engineering Shop Labor Productivity: A Framework for Analysis. Unpublished technical report, number 0365-79, Air University/ACSC, Maxwell AFB AL, April 1979.

10. Coullahan, Patrick M., Major, Chief, Project IMAGE Team. "US Air Force Work Information Management System." Unpublished article. Air Force Engineering & Services Center, Tyndall AFB FL, 3 Dec 84.

11. Donnelly, James H., Jr., et al. Fundamentals of Management (5th ed.) Plano TX: Business Publication, Inc., 1984.

12. Earls, Gary, Civil Engineering Instructor. Personal interview. AFIT/DEM, Wright-Patterson AFB OH, May 1984.

13. Fisher, Marvin N. Methodology for Measuring the Efficient Use of Available Resources in Air Force Civil Engineering Organizations. MS Thesis, GEM/LSM/84S-8. School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, September 1984 (AD-A147 110).

14. Fliakas, Perry J. "Utilization of Engineered Performance Standards (EPS) in Real Property Maintenance." Unpublished letter. Department of Defense, Office of the Assistant Secretary of Defense, Washington DC, 5 January 1979.

15. _____. "Utilization of Engineered Performance Standards in Real Property Maintenance Activities," Unpublished letter. Department of Defense, Office of the Assistant Secretary of Defense, Washington DC, 8 July 1976.

16. _____. "Utilization of Engineered Performance Standards (EPS) in Real Property Maintenance Activities," Unpublished letter. Department of Defense, Office of the Assistant Secretary of Defense, Washington DC, 20 September 1976.

17. Frey, Robert C. Handbook for Base Civil Engineering Operations Officers. Unpublished technical report, number 0930-81, Air University/ACSC, Maxwell AFB AL, May 1984.

18. Gould, Clifford L. "Expanding the Efficiency Review Program for Commercial Activities Can Save Millions (FPCD-81-77)." Unpublished letter. Director, General Accounting Office, Washington DC, 30 September 1981.

19. Gray, Miles D. "Engineered Performance Standards: A Management Tool," Air Force Engineering & Services Quarterly, 24: 18-19 (Spring 1983).

20. _____. HQ AFESC/DEMG. Telephone interview. Air Force Engineering & Services Center, Tyndall AFB FL, 8 January 1985.

21. Hanley, William F. and Frederick C. Smith. USAF Civil Engineering Work Force Productivity: An Analysis of Non-behavioral Factors Affecting Planning Technician Labor Manhour Estimates for In-house Work Requirements. MS Thesis, LSSR 24-76A, School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, June 1976 (AD-A030 244).

22. Hayward, Nancy and George Kuper. "The National Economy Productivity in Government," Public Administration Review, 38: 2-5 (January/February 1978).

23. Kepner, Charles H. Productivity: Where it Went and How and How to Get it Back. A White Paper by Kepner-Tregoe, Inc., Princeton NJ, 1982.

24. Korb, Lawrence J. "Use of Performance Work Statements and Efficiency Reviews." Unpublished letter from the Assistant Secretary of Defense, Washington DC, 27 November 1981.

25. Mali, Paul. Improving Total Productivity. New York NY: John Wiley & Sons, Inc., Publisher, 1978.

26. Mcknight, Richard D. and Gregory P. Parker. Development of an Organizational Effectiveness Model for Base Level Civil Engineer Organizations. MS Thesis, LSSR 83-13. School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, September 1983 (AD-A134 950).

27. Patton, John A. Patton's Complete Guide to Productivity Improvement. New York NY: AMACOM, 1982.

28. Skousen, K.F. et al. Principles of Accounting (2d ed.). New York NY: Worth Publishing, Inc., 1983.

29. Smith, Albert J. "Funding for EPS Program Functions." Unpublished letter. Department of Defense, Office of the Assistant Secretary of Defense, Washington DC, 28 June 1979.

30. Szilagyi, Andrew D., Jr. and Marc J. Wallace, Jr. Organizational Behavior and Performance (3rd ed.). Glenview IL: Scott, Foresman and Company, 1983.

31. Taylor, Edwin S. Base Civil Engineering Organization: Standardized versus Flexible. MS Thesis, LSSR 67-83. School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB OH, September 1983 (AD-A135 004).

32. US Department of the Air Force. Base Level Management Indicators for Civil Engineering and Services. Handbook distributed by HQ USAF Civil Engineering and Services Management Evaluation Team, Washington DC, no date.

33. _____. Base Engineering Automated Management System (BEAMS). Air Force Manual 171-200, Vol. II. Washington DC: US Government Printing Office, 13 September 1977.

34. _____. Commander's Update Briefing Handbook. Created and distributed by the School of Civil Engineering, AFIT, Wright-Patterson AFB OH, no date.

35. _____. Engineered Performance Standards for Real Property Maintenance. Training Handout HQ J3AZR55000 003-II-1, 3770 Technical Training Group, Sheppard AFB TX, November 1983.

36. _____. EPS Utilization by Command. Unpublished HQ AFESC computer reports covering FY79-85. Provided by James Ramsey, Air Force Engineering & Services Center/DEMG, Tyndall AFB FL, 15 January 1985.

37. _____. "Engineered Performance Standards (EPS) Utilization Measurement Policy Change." Unpublished letter. Air Force Engineering and Services Center/DEM, Tyndall AFB FL, September 1984.

38. _____. Operations and Maintenance of Real Property. Air Force Regulation 85-10. Washington DC: US Government Printing Office, 14 October 1975.

39. _____. Organization and Mission -- Field: 2750th Air Base Wing. Air Force Logistics Command Regulation 23-4. Headquarters, Air Force Logistics Command, Wright-Patterson AFB OH, 17 February 1982.

40. _____. Performance Management Indicators. Unpublished report developed by the Project IMAGE Workshop. Air Force Engineering and Services Center, Tyndall AFB FL, May 1984.

41. _____. Planner and Estimate Workbook, Student's Manual. Air Force Manual 85-58. Washington DC: US Government Printing Office, March 1980.

42. _____. Productivity Management A Guide For US Air Force Base Civil Engineering. Guide was prepared by the USAF Directorate of Engineering and Services in cooperation with Decision Dynamics, Inc. No date.

43. _____. Quality Assistance Program. 2750th Air Base Wing, Civil Engineering Squadron Operating Instruction 85-7. Wright-Patterson AFB OH, 10 January 1985.

44. _____. Real Property Maintenance Activity Functional Review. Unpublished technical report. Air Force Engineering and Services Center, Tyndall AFB FL, January 1983.

45. _____. Resources and Work Force Management. Air Force Regulation 85-1. Washington DC: US Government Printing Office, 21 May 1982.

46. _____. Slides on background of Engineered Performance Standards (EPS). Unpublished Material. Slides used by HQ AFESC EPS Utilization Team. Provided by James Ramsey, Air Force Engineering and Services Center/DEMG, Tyndall AFB FL, no date.

47. US Department of Defense. DoD Productivity Program. DOD Directive 5010.31. Washington DC: US Government Printing Office, 27 April 1979.

48. _____. Productivity Enhancement, Measurement, and Evaluation - Operating Guidelines and Reporting Instructions. DOD Instruction 5010.34. Washington DC: US Government Printing Office, 4 August 1975.

49. US Government. Department of Defense Appropriations for 1979. Hearings before a subcommittee of the Committee on Appropriations House of Representatives, Ninety-Fifth Congress, Second Congress, Part 7-Supply Operations and Management, Real Property Maintenance and Repair, and Reserve Forces Management. Pgs 139-231, US Government Printing Office, Washington DC: 1978.

50. _____. The United States Budget in Brief FY 1985. Washington DC: US Government Printing Office, February 1984.

51. Webster's New International Dictionary (2d ed. unabridged). Springfield MA: G. & C. Merriam Co., 1955.

52. Wilson, Louis L., Jr., General, USAF. "People: Our Most Important Resource," TIG Brief: 2 (25 February 1977).

53. Wright, Clifton D., Major General, Director, USAF Engineering and Services. "Moving Forward With a Strategic Plan," Air Force Engineering & Services Quarterly, 25: 3-6 (Spring 1984).

VITA

First Lieutenant Juan Ibanez Jr. entered the United States Air Force in February 1975 and became a Law Enforcement Specialist. In 1979 he was accepted into the Airman Education and Commissioning Program and in 1981 graduated from Texas A&M University with a Bachelor of Science degree in Civil Engineering. After receiving a commission through Officers Training School, he was assigned to the 96th Civil Engineering Squadron, Dyess AFB, Texas. While at Dyess AFB, he held positions as Base Environmental Planner, Chief of Readiness and Logistics, and Chief of Resources and Requirements. In June 1984 he entered the School of Systems and Logistics, Air Force Institute of Technology.

Lieutenant Ibanez is a graduate of Squadron Officers School and a registered Engineer-in-Training in the state of Texas. He is a member of Tau Beta Pi, Chi Epsilon, Phi Kappa Phi, and Sigma Iota Epsilon.

Permanent address: 15816 16th Ave Court E.
Tacoma, Washington 98445

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS A160 925
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release: distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFIT/GEM/LSM/85S-7	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION School of Systems and Logistics 6b. OFFICE SYMBOL (If applicable) AFIT/LSM	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) Air Force Institute of Technology Wright-Patterson AFB, Ohio 45433	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification) See Box 19	

12. PERSONAL AUTHOR(S)
Juan Ibanez, Jr., B.S., 1st Lt, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
MS Thesis	FROM ______ TO ______	1985 September	121

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Civil Engineering, Engineered Performance Standards (EPS), Productivity, Work Information Management System (WIMS)
13	2		
5	1		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Title: A PERFORMANCE BASED PRODUCTIVITY INDICATOR FOR BASE CIVIL ENGINEERING OPERATIONS BRANCHES

Thesis Chairman: Jeffrey S. Thomas, Captain, USAF

Approved for public release: IAW AFR 190-1.
Lynn Wolaver 11 Sept 85
LYNN E. WOLAVER
Dean for Research and Professional Development
Air Force Institute of Technology (AFC)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
Jeffrey S. Thomas, Captain, USAF	513-257-76578	HQ AFLC/DE

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

Performance initiatives by the Office of the Secretary of Defense and the Department of the Air Force have resulted in many strategies to increase productivity, yet no practical nor definitive approach to measure civil engineering productivity now exists. This thesis applies a Project IMAGE productivity indicator designed to quantify the Base Civil Engineering Operations Branch's "Customer Service" output. In concept, the indicator uses estimated work hours, Engineered Performance Standards, applied to job and work orders, and processes these hours against timeliness, quality, facility-type, and work priority factors. The result is a weighted production count which allows relative productivity measurement. The primary objective of the thesis was to demonstrate application of the concept by using the Work Information Management System and data from the 2750th Civil Engineering Squadron. The study produced a computer program to implement the productivity concept. Research results indicate the concept can be applied using data currently maintained by civil engineering. Widespread use of this concept requires additional research.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

END

FILMED

12-85

DTIC